A GENERAL EQUILIBRIUM ANALYSIS OF POTENTIAL USE OF NATURAL RESOURCES REVENUE IN NIGER

By

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2003

Submitted to the Faculty of the
Graduate College of the
Oklahoma State University
in partial fulfillment of
the requirements for
the Degree of
DOCTOR OF PHILOSOPHY
December, 2008

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ACKNOWLEDGEMENTS

Thanks to God, the almighty and the merciful, for giving the strength and health to write this dissertation.

I would like to thank Dr. Michael Applegate, my committee chair, for his continuing support and help. There is no doubt that this dissertation could not have been completed without his help. I would like also to thank the other members of my committee, Dr. Dan Rickman, Dr. Keith Willett, and Dr. Francis Epplin for their support and encouragement

Special thanks to Dr. Ronald Moomaw, the head of the Economics Department, and Dr. Jim Fain, the graduate coordinator, for their continual renewal of my assistantship throughout my stay in the Department of Economics, without which it would have been be extremely difficult to finish this work. Their encouragement and support reassured me and gave me courage to finish this study.

I would like to thank my parents for what they did and continue to do to help me succeed in life. I can only pray to God to repay the good deed they have done for me. Special thanks to my brothers and sisters for their moral support and encouragement.

Finally, to my beloved wife, Ouma, and my two wonderful children, Mounir and Nadira, I know it was hard to see me leaving home almost every day while completing this work. To show my gratefulness, I am dedicating this dissertation to them.

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CHAPTER I

INTRODUCTION

Niger is a land-locked, arid country situated in West-Africa. With an estimated 13 million population, it is almost twice the size of Texas in terms of land. Around 90% of the population lives in the southern part of the country, within 150 miles of the Nigerian border where the weather is favorable for agriculture. Eighty-one percent of Nigeriens live in rural areas. Niger has the highest population growth rate in the world (3% per year) and 49% of the population is less than 15 years old. Agriculture is the most important sector of the economy (45 % of GDP) and is mostly practiced in the southern part of the country. The agricultural sector employs 80% of the population. The sector has low productivity and is vulnerable to climate variability due to recurrent droughts (1968-74, 1983, and 2004). In 2004, a drought combined with a locust invasion had devastating effects on rural households. Droughts also had devastating effects on livestock, another important sector of the Niger economy. During the 1984 drought, more than 50% of the cattle died, reducing household wealth. As in most developing countries and especially in Niger, livestock is seen as a form of investment.

According to a United Nation Development Report, Niger has the lowest human development index in the world, mainly due to a very low combined primary, secondary, and tertiary gross enrollment ratio; and more than 60% of the population live on less than one dollar a day.

Nevertheless, Niger has tremendous reserves of natural resources, namely uranium, oil, natural gas, and gold. However, only uranium and gold are exploited. Gold was produced using rudimentary technology until 2004, when industrial production of gold started. Uranium is by far the most import natural resources in the country. In fact, Niger is the world's third- to fifth-largest producer of uranium. With the increasing interest by many countries in developing nuclear energy, world demand for uranium is increasing and so is the price of uranium, which increased by almost 900% over just three years (2005, 2006, and 2007). To take advantage of this favorable market condition, the government plans to double production in the next few years.

A likely increase in price and the quantity of uranium exported is seen by many observers as an opportunity for growth and prosperity in Niger. However, some recent studies have found a negative correlation between growth and a natural resource boom. Sachs and Warner (1999) among others found that resource booms seem to have done little to generate long-term growth, and may in fact have hindered growth on average. For example Congo and Nigeria, two natural resource abundant countries, experienced little or no growth over 40 years. Ross (2001) found that natural resources are strongly associated with unusually bad conditions for the poor. Gylfason (2007) distinguished five channels through which a boom in natural resources can negatively affect an economy: corruption, neglect of education, reduction of private and public investment, crowding out of financial capital, and reduced competitiveness. The reduction in competitiveness is primarily due to a phenomenon called Dutch disease. "Dutch disease" refers to the negative effect of a booming (mining) sector on the non-booming sector (manufacturing) through an appreciation of the real exchange rate (RER). For example, a boom in the mining sector tends to increase overall price levels in an economy, thereby increasing inflation. The consequence of inflation is an appreciation of RER. The non-booming manufacturing sector will become uncompetitive and therefore will contract.

The resource curse thesis is not without critics. Some researchers found that natural resources are not to be seen as a curse but as a blessing. Among others, Sala-i-Martin et al. (2004) found that the fraction of GDP in mining has a positive relationship with growth and they conclude that economies with a larger mining sector tend to perform better. Whether the resource curse thesis holds or not, the problem that faces many countries expecting a windfall from a natural resource boom, like Niger, is how to manage or spend the windfall to promote growth and prosperity. The answer to the above question is very important to policy makers in Niger (or any developing countries expecting a commodity windfall) who see this as an opportunity to get out of the vicious cycle of poverty. Moreover, the problem needs to be studied in depth at the country level, taking into account country-specific needs.

RESEARCH QUESTION

The main research question is, then, "how should the government of Niger spend the natural resource export revenue to reduce the risk of Dutch disease and to promote economic growth and prosperity?"

RESEARCH OBJECTIVE

Considering the above question, this study has general objectives. The first objective is to use a recursive, dynamic, general equilibrium model to quantify the inflow of capital from natural resource exports. The second objective is to model the effects of two specific uses of uranium revenue in Niger: investment in education and investment in infrastructure.

The specific objectives are to determine the impact of the above spending strategies on:

1. Consumer Price Index
2. Real GDP
3. Household Welfare
4. Inequality

OUTLINE OF THE STUDY

The dissertation is ordered as follows. The next chapter introduces key features of Niger's economy. The third chapter reviews the literature. The emphasis here is on the ongoing research over the natural resource curse. Chapter IV describes the model, including data and calibration. The impact of a natural resource windfall is analyzed in Chapter V, whereas the impact of specific uses of uranium revenue is analyzed in chapter six. Chapter VII concludes the study with some policy implications.

CHAPTER II

BACKGROUND

INTRODUCTION

This chapter presents the salient features of Niger's economy. The focus is on factors that have influenced Niger's past economic performance: The vulnerability of the agricultural and uranium sectors to external factors. Focusing on these salient features sheds some light on the questions this dissertation attempts to answer.

Niger ranks 174 out of 177 countries in terms of human development according to the United Nations Human Development Report of 2007/2008. Poverty is widespread. According to the latest household survey (2006), 62% of the population is poor.[1]

Niger has a mostly agrarian economy. The agricultural sector is the most important sector of the economy. It employs more than 80% of the economically active population and generates more than 38% of GDP (see Table 1). The services sector accounts for 44% of GDP but only employs 11% of the labor force. This sector is composed of commerce, government, financial services, transport, hotels and restaurants, and telecommunication. The government sector and commerce sector are by far the two major components of the services sector. The industrial sector is mainly composed of mining, manufacturing, and construction and accounts for 18% of GDP. The mining sector made a significant contribution in the 70s and early 80s due to a favorable global

[1] A report (2006) by the National Institute of Statistics of Niger defines "poor" as a person living under 397 CFA~$0.6 8 a day in an urban area or 290~$0.5 CFA in a rural area.

Uranium market conditions. However, the share of the mining sector in GDP shrank after the end of the uranium bonanza in the early 80s.

AGRICULTURE

The major problem that faces Niger's economy is its vulnerability to external shocks resulting from uncertain rainfall and insect invasions. As a result of this vulnerability, agricultural output is very volatile in Niger. For example, the drought and locust invasion in 2004 was devastating: output fell sharply and prices of sorghum and millet rose to 80% of the previous five-year average. Drought also has an important impact on livestock, which is the most important source of income and wealth for rural households. In fact, drought has two effects on livestock: price and quantity effects. The quantity effects tend to reduce the quantity of livestock due to loss of pasture. The price effect is due to an oversupply of livestock in the market by households who are trying to cope with the high prices of food like millet and sorghum, whose prices usually increase during a drought period. For that reason, the price of livestock tends to fall during a drought. These effects combine to deprive households of a key source of income.

Agricultural output fluctuations also affect the growth rate of GDP. Figure 1 shows that real GDP growth mimics the growth of agricultural output. Change in the growth of real GDP depends on agricultural output, which depends on rainfall. For example, higher GDP growth rates are associated with exceptionally favorable weather conditions (1998) whereas lower growth rates are associated with negative climate shock (1994). The major challenge that faces the country is to find a way of reducing the vulnerability of the economy to climate shocks. Therefore, efforts have to be made to reduce the reliance on rain-fed agriculture.

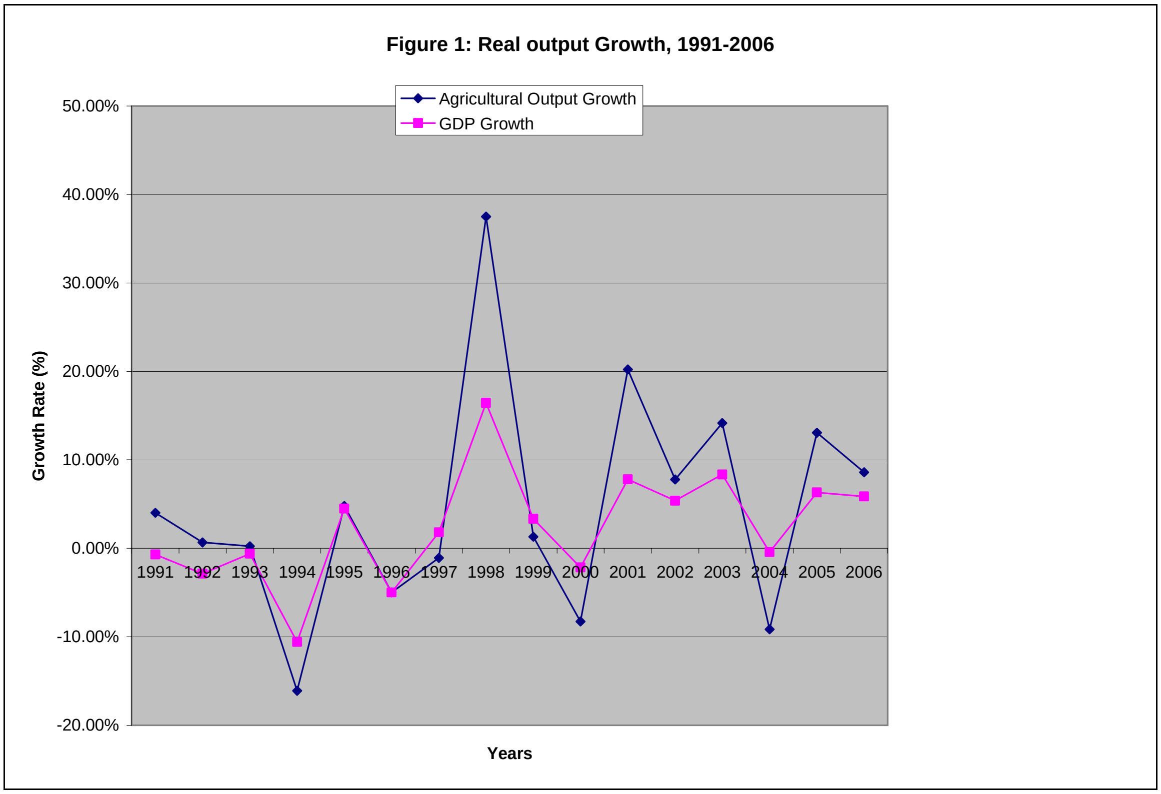


Figure 1: Real output Growth, 1991-2006
Agricultural Output Growth
GDP Growth
Growth Rate (%)
50.00%
40.00%
30.00%
20.00%
10.00%
0.00%
-10.00%
-20.00%
1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006
Years

Table 1: Composition of GDP by Sections, 1996 -2006 (Millions of CFA)

	1996	**1997**	**1998**	**1999**	**2000**	**2001**
AGRICULTURAL SECTOR	316,743.00	322,572.00	466,140.00	461,360.00	435,647.00	544,451.00
Agricultural	187,234.00	183,479.00	289,452.00	298,756.00	261,788.00	354,739.00
Livestock	94,537.00	100,697.00	133,403.00	118,966.00	125,876.00	134,570.00
Forestry	34,972.00	33,759.00	43,284.50	43,637.60	47,983.80	41,293.20
Fishing		4,637.00				13,849.00
INDUSTRIAL SECTOR	136,292.00	145,931.00	150,825.00	142,828.00	148,404.00	159,860.00
Mining	36,120.00	38,457.00	32,884.70	25,129.20	31,752.30	30,996.80
Manufacturing	62,269.00	66,016.00	74,019.00	77,785.00	74,944.60	81,946.50
Utilities	17,073.00	17,279.00	16,270.00	13,326.00	14,423.00	15,458.00
Construction	20,830.00	24,179.00	27,651.50	26,588.10	27,284.20	31,458.50
SERVICES SECTOR	419,772.00	441,742.00	485,394.00	506,687.00	531,169.00	540,639.00
Commerce	148,517.00	158,707.00	147,040.00	154,726.00	158,709.00	163,301.00
Auto Repair						
Hotel Restaurant	12,618.00	13,835.00	15,433.40	16,427.00	16,548.20	18,145.10
Transports	53,810.00	55,602.00	64,582.90	63,337.70	66,405.30	70,787.20
Telecommunications	6,321.00	7,988.00	8,359.00	8,178.00	10,775.00	11,624.00
Financial Services	7,595.00	7,490.00	8,875.00	9,031.00	9,377.00	10,858.00
Housing	93,830.00	99,730.00	107,009.00	113,292.00	117,700.00	52,863.00
Other Services	7,412.00	7,501.00	8,671.13	8,664.00	9,143.03	79,636.00
Public Administration	94,134.00	95,668.00	131,159.00	139,343.00	149,012.00	141,308.00
SIFIM*	-4,465.00	-4,779.00	-5,735.00	-6,312.00	-6,501.00	-7,884.00
VALUE ADDED TAX	36,900.00	43,300.00	64,429.00	66,972.00	71,058.00	84,496.00
GDP	909,707.00	953,545.00	1,166,788.00	1,177,847.00	**1,186,278.00**	1,329,446.00
Real GDP	9,842.12	10,022.55	11,730.05	12,120.26	**11,862.78**	12,781.91
CPI	92.43	95.14	99.47	97.18	**100**	104.01
Real GDP GROWTH RATE (%)		1.83%	17.04%	3.33%	-2.12%	7.75%

Institut National de la Statistique *
Imputed production of banking services, statistical adjustment

Table 1 (continued)

	2002	2003	2004	2005	2006
AGRICULTURAL SECTOR	602,812.00	676,833.00	615,990.00	751,203.00	816,391.00
Agricultural	400,849.00	382,385.00	324,512.00	444,239.00	502,714.00
Livestock	140,948.00	204,137.00	208,364.00	218,050.00	229,634.00
Forestry	44,731.00	45,936.00	48,020.80	50,515.00	52,929.00
Fishing	16,284.80	44,374.50	35,093.50	38,399.00	31,114.00
INDUSTRIAL SECTOR	165,555.00	176,230.00	182,202.00	195,206.00	198,295.00
Mining	29,067.20	29,668.10	31,428.10	35,659.00	28,634.00
Manufacturing	87,466.80	90,752.60	94,107.10	98,349.00	101,055.00
Utilities	15,042.00	19,174.40	17,969.50	19,576.00	24,522.00
Construction	33,978.50	36,635.00	38,697.30	41,622.10	44,084.00
SERVICES SECTOR	568,276.00	583,577.00	616,492.00	674,118.00	703,609.00
Commerce	170,521.00	172,906.00	182,079.00	200,159.00	209,804.00
Auto Repair	30,371.00	31,806.10	34,349.20	35,282.00	37,099.00
Hotel Restaurant	18,848.00	20,900.30	23,065.00	24,963.00	26,089.00
Transports	75,327.30	78,138.60	88,062.80	90,796.00	96,115.00
Telecommunications	11,972.00	15,841.40	18,431.60	24,272.00	27,298.00
Financial Services	9,694.00	13,464.60	17,863.40	20,883.50	22,762.70
Housing	52,122.00	52,241.00	55,635.80	56,785.00	58,809.00
Other Services	58,644.00	59,378.60	64,541.90	72,863.00	75,858.00
Public Administration	148,803.00	149,348.00	145,182.00	162,713.00	165,818.00
SIFIM*	-8,026.00	-10,448.00	-12,719.00	-14,599.00	-16,044.00
VALUE ADDED TAX	102,888.00	97,667.00	115,759.00	134,524.00	141,164.00
GDP	1,439,531.00	1,534,306.00	1,530,443.00	1,755,051.00	1,859,459.00
Real GDP	13,486.33	14,609.66	14,535.50	15,463.00	16,375.68
CPI	106.74	105.02	105.29	113.5	113.55
Real GDP GROWTH RATE (%)	5.51%	8.33%	-0.51%	6.38%	5.90%

Institut National de la Statistique *
Imputed production of banking services, statistical adjustment

From this perspective, Niger's government has made the development of irrigation as a "Cheval de Bataille" on all its poverty reduction strategies[2]. In 2007, the government secured funds for the Kandadji Dam Project. Several studies conducted by the ministry of agriculture have shown that the Kandadji Dam, if it is realized, will significantly reduce Niger's recurrent food crises due to drought. However, the dam project may offer only a short term solution to the problems that face Niger. Diversifying

[2] According to the World Bank website: "**Poverty Reduction Strategy Papers (PRSP)** describe a country's macroeconomic, structural and social policies and programs to promote growth and reduce poverty, as well as associated external financing needs. PRSPs are prepared by governments through a participatory process involving civil society and development partners, including the World Bank and the International Monetary Fund (IMF)."

the economy away from agriculture should be the goal of any long-term economic development planning. Doing so will require tremendous amounts of human and physical capital. Investment in human capital and infrastructure should play a crucial role in any long-term development planning in Niger.

Another challenge that Niger's economy faces is a high fertility rate. Indeed, Niger has the highest fertility rate in the world (on average 7 children per woman). As a result, Niger has an extremely high population rate increase, 3.3 % per year, the third highest rate in the world. The results are an unsustainable pressure on the environment, increasing demands, in the area of social services, and a negative impact on food security. Moreover, this high population growth rate has a substantial negative impact on per capita growth rate. For example in 2004, the drop in agricultural output resulted in a negative growth rate of per capita income of -2.7%.

NATURAL RESOURCES

Niger has abundant deposits of natural resources: uranium and coal in the north; iron, gold, and phosphates in the west; and oil in the east. Indeed, Niger is the third- to fourth-largest world producer of uranium. Niger's first commercial uranium mine began operating in 1971, and today uranium represents more than 50% of Niger's total export (see Table 2)

Table 2: Export Composition, 2000-2006 (Millions of CFA)

	2001	2002	2003	2004	2005	2006
Uranium	63,048.00	62,456.00	65,520.00	70,140.00	78,540.00	79,632.00
% in Total Export	52.96	53.14	56.46	54.81	47.69	55.36
Gold				8,976.00	34,154.00	19,528.00
% in Total Export				7.01	20.74	13.58
Livestock	32,441.00	27,378.00	26,700.78	22,803.31	19,840.42	21,179.92
% in Total Export	27.25	23.29	23.01	17.82	12.05	14.72
Agricultural Products	16009	16,009.00	17,630.00	16,353.71	18,566.28	16,430.08
% in Total Export	13.45	15.00	14.09	14.51	9.98	9.87
Other Products	7,544.00	10,071.00	7,479.92	7,475.89	15,730.31	9,312.03
% in Total Export	6.34	8.57	6.45	5.84	9.55	6.47
Total	119,042.00	117,535.00	116,054.40	127,961.48	164,694.81	143,852.31

Source : Institut National de la Statistique

During most of the 70s and early 80s, world demand for nuclear energy increased due to the oil shocks of 1973. World prices of uranium more than tripled from 1973 to 1978 (see Figure 2). With the opening of a second uranium mine, Niger’s uranium production increased from less than 1,500 tons in 1976 to more than 4,000 tons in 1980.

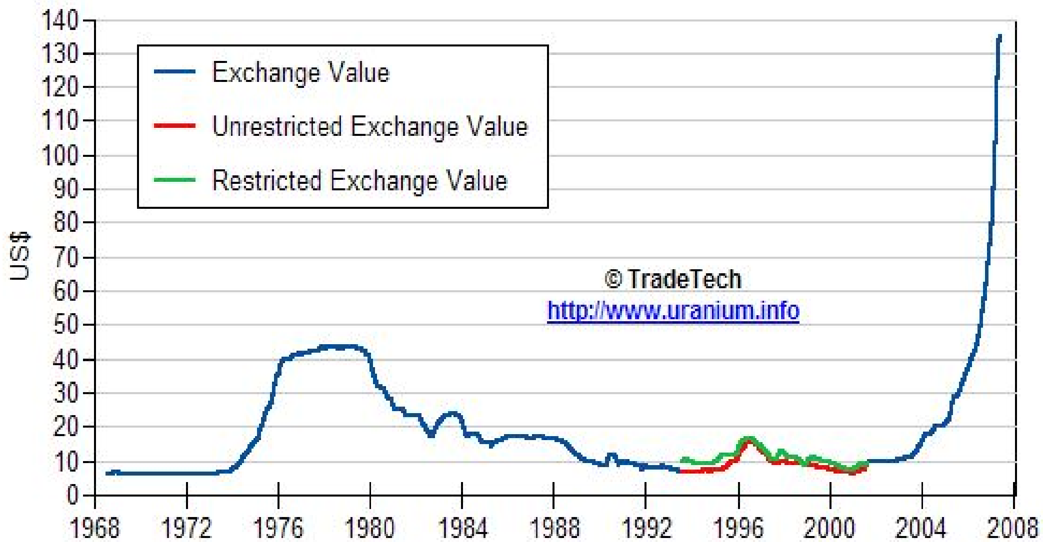
The price shock had a positive impact on Niger’s economic performance from 1979 to 1982. The annual growth rate of GDP for that period was 5.1%. Niger’s budgetary revenue increased considerably, and as a result public spending rose significantly. Development expenditure during that period was concentrated on infrastructure investment (roads, buildings, and transportation). Some signs of Dutch disease were observed in the economy. For example, inflation was almost 25% during that period, despite Niger’s membership in the Western Africa Economic and Monetary Union (WAEMU), which means Niger does not have control over its money supply.

The uranium bonanza did not last long, as the world uranium market collapsed in 1983 because the world supply of uranium grew faster than the demand. Niger’s export receipts declined as both the quantity exported and the price negotiated with the French importer fell. The consequences were severe. Aggregate real GDP declined by 0.2 percent per year. Fiscal revenue collected through uranium royalties and export duties decreased sharply. The government was forced to slash development expenditures by 21.8 percent in an effort to reduce its fiscal deficit.

Until 1975 Niger's foreign debt was fairly small. During the uranium boom, the government was able to borrow money in the international financial market and used future uranium earnings as collateral. Foreign borrowing increased tremendously beginning in 1976. After 1981, Niger's ability to obtain credit in the international financial market declined. The government-owned light manufacturing industries which had been created during the boom shut down. The uranium fallout combined with the drought of 1984 compelled the government to adopt structural adjustment programs supported by the World Bank. The essence of the program was a reduction in government expenditures and a rescheduling of debt.

As Figure 2 suggests, the price of uranium has increased sharply during the past few years. Today, nuclear energy is seen by many experts as a potential energy source in response to global warning. Countries like the United Arab Emirates, Libya, and Iran, to name a few, have all expressed their desire to develop nuclear energy. Even U.S law-makers and other politicians are giving serious consideration to the possibility of using nuclear energy as a means of reducing dependence on foreign oil. In addition, China and India are aggressively searching for this precious combustible to use in their existing nuclear reactors. Just like the 70s, exploration for uranium has responded positively to the rapid increase in price.

Figure 2: Uranium Spot Price



Source: TradeTech. Website: www.uranium.info

Niger's government has liberalized its mining sector and has recently granted multiple uranium exploration permits to companies from China, India, France, Canada, and South Africa. The aim of Niger's government is to double the production of uranium in the coming years. In this regard, two mines are scheduled to open by 2011: Imouraren and Teguida. The Imouraren mine is expected to produce 4000 tons a year and the Teguida mine is expected to produce 700 tons a year. French nuclear energy giant Areva, the main stakeholder in the two currently active mines in the Agadez desert region, holds the rights for the Imouraren deposit. China Nuclear International Uranium Corp. (Sino-U) is developing Teguida. The Niger government hopes the new mines will help it cash in on booming world demand for uranium to be used as a nuclear fuel in power stations and atomic submarines (International Atomic Energy Agency Report 2005).

In June, 2008, the government signed a contract with a Chinese company (China National Oil and Gas Exploration and Development Corporation) to exploit oil reserves in the eastern part of Niger. The contract allows the construction of an oil refinery (the first in the country) with a 2000 Km pipeline connecting the oil wells to the refinery. The refinery is scheduled to begin operating in 2011 with a capacity of 20,000 barrels a day. Niger's daily oil need is approximately 7,000 barrels. The total known oil reserve is estimated at 324,000,000 barrels. This reserve was discovered in the 70s but was judged to be insignificant for exploitation at that time. The total cost of the project is estimated at 1 billion dollars. This project will create an estimated 1,500 new jobs during the construction phase and 500 new jobs during the exploitation phase, according to a government official.

CONCLUSION

Niger's economy is very dependent on external factors. Agriculture, which is the most important sector in the economy, is vulnerable to climate variability. The uranium export revenue declined after the 80s due to the collapse of the price, though this trend has now reversed. The country is experiencing an inflow of capital due to mining projects. In the next three years, the Imouraren uranium mine is scheduled to become operational, placing Niger in second place in the world as a producer of uranium. Also, in 2011 Niger will export its first barrels of oil. These are excellent opportunities for the country, which has ranked at the bottom in terms of the human development index. However, as we will see in the next chapter, natural resource exporting countries still face the problems of under-development and widespread poverty despite years of natural resource exploitation.

CHAPTER III

REVIEW OF LITERATURE

INTRODUCTION

Development economists have long been concerned about the impact of natural resource exportation on the development process of countries. Adam Smith (1776) wrote the following:

> Projects of mining, instead of replacing the capital employed in them, together with the ordinary profits of stock, commonly absorb both capital and stock. They are the projects, therefore, to which of all others a prudent law-giver, who desired to increase the capital of a nation, would least choose to give any extraordinary encouragement… . (p. 562).

Raul Prebisch (1950, 1964) and Hans Singer (1950) studied the role of trade structure in the growth of nations. They argued that primary commodities exporters (developing countries) find themselves disadvantaged in trading with primary commodities importers (industrialized countries) due to deteriorating terms of trade. This is known in the literature as the Prebisch-Singer hypothesis. Baldwin (1966) and Hirschman (1958) have argued that the mining sector has few linkages with the rest of the economy. According to Hirschman, the mining sector is an enclave unlike the manufacturing sectors, which tend to have backward and forward linkages or externalities. Past studies focused on primary products and natural resources in general. However, recently, the debate over the impact of natural resources on the economy has resurfaced and has now moved from natural resources in general to oil and other minerals.

The oil shocks of the 70s were an opportunity for oil-exporting countries to collect large amounts of oil and other mineral windfalls. These windfalls should have provided a "big push"[3] to their economies. Sachs and Warner (1999a) argue that the notion that resources rent can provide a "big push" depends on whether there are increasing-returns-to-scale in non-tradeables sectors. Indeed, increasing-returns in non-tradeables sectors mean that the sector is capable of inducing economic growth alone. However an empirical study has shown that the tradeables sectors like manufacturing tend to have increasing-returns-to- scale.

This chapter is structured as follows: the next section summarizes the general literature on natural resources and economic growth, the subsequent section deals with the specific issue of Dutch disease, the third section discusses the literature on human capital and the resource curse, and the last section reviews the literature on how the resource curse can be avoided.

NATURAL RESOURCES AND ECONOMIC GROWTH

Many authors have studied the link between natural resources and economic growth. Many of these authors found a negative relationship between natural resource abundance and economic growth (Auty, 2001; Sachs and Warner, 1999b among others). For example, Sachs and Warner (1995) found that economies with a high ratio of natural resource exports to GDP in 1971 tended to have low growth rates during the subsequent period (1971-89). Their results remain robust even after controlling for variables that are

[3] According to the "Big Push" Theory (Rosenstein-Rodan, 1961; Murphy et al., 1989), resource rent or aid should facilitate the process of industrialization of developing countries, their investing the rent in many sectors of the economy. The basic idea of the big push theory is that developing countries need to expand demand.

believed to affect growth, such as initial per capita income, trade policy, government efficiency, investment rates, and other variables.

In their recent study using U.S. data, Papyrakis and Reyer (2007) found that even in a relative homogeneous sample, resource abundance can have a significant negative impact on economic growth by affecting various economic fundamentals such as investment levels, schooling rates, and openness. Furthermore, they added that the natural resource curse is not only a problem in countries with weak institutions, but is potentially a common threat to both developing and developed economies.

However, such results are far from being unanimous. Moreover, the results tend to be very sensitive to the period chosen and the data used to measure natural resource abundance. Lederman and Maloney (2007) found that Sachs and Warner's results were not robust to a variety of measures of natural resource abundance and estimation techniques. Although there are two schools of thought, the present literature focuses more on the transmission channels of the resources curse. Gylfason (2007) distinguished five channels through which natural resources can negatively affect an economy: corruption, neglect of education, reduction of private and public investment, crowding out of financial capital, and reduced competitiveness.

Auty (2001) argued that resource-abundant countries engender political states that are predatory or corrupted. According to Collier et al. (2005), leaders of natural resource exporting countries choose to loot resource rents rather than invest in the public good for four reasons. First, when the elites' time horizon for staying in power is short, they are more likely to loot resource rents. Second, empirical studies have proven that the smaller the ruling ethnic group, the greater the incentive to prioritize redistributions of the rents among the ruling group over growth. Third, looting is more likely when public assets are very valuable relative to the income of the society and fourth, when democratic electoral competition degenerates into patronage politics.

DUTCH DISEASE

Although, there are many channels through which natural resources negatively affect the economy, the Dutch disease channel has received more attention in the literature. Originally, the term “Dutch disease” referred to the negative effect of a booming sector on the non-booming sectors through an appreciation of the real exchange rate (RER). Corden and Neary (1982) were among the first researchers to study the effect of a booming sector on the other sectors in an economy. They distinguished two effects of a booming sector: the resource movement effect and the spending effect. They argued that the boom in the energy sector raises the marginal products of the mobile factors employed there and so draws resources out of other sectors, giving rise to various adjustments in the rest of the economy. They called this kind of effect the resource movement effect. The spending effect occurs when the booming sector raises real income in an economy, which increases spending on services like leisure, causing real exchange rate appreciation. Benjamin et al. (1989) argued that developing countries are more likely to suffer from the spending effect because capital and labor in the mining sector are primarily foreign. However, in Niger, labor is primarily domestic in the mining sector, although capital is foreign. Even though labor is domestic, the uranium sector is less likely to draw labor from the manufacturing sector. Indeed the mining sector in Niger is unskilled-labor-intensive whereas the manufacturing sector tends to be skilled-labor-intensive. For the reason mentioned above, the present study will only focus on the spending effect.

Other papers have approached the Dutch disease issue in the context of learning by doing (LBD). Most of the literature on LBD and Dutch disease assumes that LBD is only specific to the tradeable manufacturing sector (Wijnbergen, 1984; Krugman, 1987; Sachs and Warner, 1995). The idea is that an inflow of a windfall[4] resource tends to appreciate the real exchange rate. The appreciation of the real exchange rate lessens the manufacturing sector, which is a source of productivity growth due to LBD. The net effect will be a growth disaster for the economy receiving the windfall. Gylfason et al. (1997) extended the literature and showed that a boom in the primary sector not only harms the high-skilled secondary sector through an appreciation of the real exchange rate, but also generates real exchange uncertainty. Sachs and Warner (1995) argued that if neoclassical, competitive conditions prevail in the economy, there will be nothing harmful about the shrinkage of the manufacturing sector. But if, however, the manufacturing sector is characterized by externalities in production, then the shrinkages the manufacturing sector caused by resource abundance can lead to a socially inefficient decline in growth.

Unlike most papers on LBD and Dutch disease, Torvik (2001) assumed that both tradeable and non-tradeable sectors experience LBD and that there is a learning spillover across the two sectors. He concluded that when faced with such a model, the real exchange rate depreciates in the long-run. In contrast to most literature, he found that production and productivity in both sectors may go up or down depending on the

[4] The inflow of capital need not to be only from a resource windfall. It can be from emigrant remittances, aid, or any other type of capital that can be categorized as a foreign exchange gift.

characteristics of the economy. Torvik (2005) further elaborated on the effect of Dutch disease on the economy. He found that some Dutch disease is always optimal and that lower growth in resource-abundant countries may not be a problem in itself, but may be part of an optimal growth path.

EDUCATION AND THE RESOURCE CURSE

A growing amount of literature focuses on the link between education and the resource curse. These studies found that countries with a low level of education tend to suffer the most from the resource curse. For example, Bravo-Ortega and Gregorio (2007) studied the role of education in the development trajectory of two natural-resource-abundant regions: Scandinavia and Latin America. Their result indicated that education was one of most important factors in why Scandinavian countries out-performed Latin American countries in the 90s even though both had similar levels of GDP per capita during late the19th and early 20th centuries and both were resource-abundant regions. The reasoning for how a low level of education affects the economic performance of resource-abundant countries is very similar to that for Dutch disease. Indeed, the agricultural and mining sectors tend to be very low-skilled and labor intensive. As a result, natural-resource-abundant countries have a tendency not to invest in high-skilled labor at the level that it should. However, the manufacturing sector shrinks because of the lack of adequate high-skilled labor. In fact, Suslova and Volchkova (2007) found that high-skilled labor-intensive industries in resource-abundant countries grow more slowly than low-skilled labor-intensive industries (agriculture and mining). According to Gylfason (2001), natural-resource-abundant countries tend to neglect education because they can cash in their natural resource without the reliance on human capital. However countries that do not have natural resources will have to rely on other things to promote growth, like the development of human capital.

An abundance of natural resources can affect income inequality through the neglect of education. For example, Leamer et al. (2002), using a multi-cone Heckscher-Ohlin trade model, found that the abundance of natural resources in Latin America is a major cause of the region's high income inequality. Moreover, they argued that the availability of natural resources has delayed the emergence of manufacturing sectors. This delay has contributed to the neglect of educational systems in Latin America, which produce human capital, a crucial ingredient for the development of manufacturing sectors.

The link between education and the resource curse is worth mentioning because Niger has one of the lowest school enrollments in the world (see World Development Report, 2007). One possible use of a resource windfall would be to invest in education. Indeed, the present study proposes to use the windfall to accumulate human capital by investing in education.

THEORY OF HOW THE RESOURCE CURSE MIGHT BE AVOIDED

The literature on the resource curse has focused more on the existence of the curse and its transmission channels than on how the resource curse can be avoided. Apart from some general policy advice, only few studies examined ways to escape the resource curse.

The literature on how the resource curse might be avoided can be classified into six analytical frameworks (Stevens, 2003).

1. Leave the resources in the ground. Ross (2001) believed that the best course of action for a country like Niger is to avoid export-oriented extractive industries altogether and instead work to sustain and develop its agriculture and manufacturing sectors. But this is an option not likely to be adopted by countries that are extremely poor. In fact, Ross himself recognized that leaving the resource in the ground will not happen and proposed instead export diversification, transparency, and monitoring and control of resource revenue.
2. Diversification is another policy action to limit the negative effect of the resource curse in general and Dutch disease in particular. Auty (1994) argued that the lack of diversification is an important explanation for poor economic performance in mineral-based economies. However, diversification has proven to aggravate the problem of the resource curse through trade policies. Sachs and Warner (1995) found a U-shaped curve between openness and natural resource abundance. Their reasoning is as follows. Natural resource exports squeeze the manufacturing sector, which is a source of productivity as in the case of Dutch disease. For countries that are not natural-resource-export-intensive, this squeeze will call for protectionism of local industries in the form of trade restrictions, subsidies, and other barriers to trade. However, for countries that are heavy exporters of natural resources like the Middle Eastern countries, there is no need to develop an extensive industrial sector other than the oil-based sector.
3. The third policy option is to sterilize the resource windfall. Revenue sterilization refers to the fact that the impact of resource revenue on the economy needs to be neutralized. This can be achieved by accumulating government budget surpluses

like Indonesia did in the seventies (Usiu, 1996). Indeed, most countries that have managed to escape the resource curse hypothesis adopted prudent macroeconomic policies. One common policy mistake for countries that experience a natural resources boom is to increase national debt using the expected revenue as collateral. This was exactly what the Niger government did during the first uranium boom (1979 to 1982). During that period, the government of Niger, using its store of yet un-mined uranium as collateral, borrowed 330.3 billion of CFA, equivalent to 71.5 percent of the value of uranium exports from 1977 to 1982 (Dorosch, 1994). In fact, in a recent study, Manzano and Rigobon (2007) used panel data and found that the resource curse effect was mainly due to the fact that resource exporting countries decided to use the high commodity prices in the 1970s as implicit collateral and found themselves on a debt overhang when commodity prices fell in the 1980s. They concluded by saying that the resource curse is caused by credit market imperfections.

4. One major problem that natural-resources-exporting countries face is price fluctuations in international commodities. Fluctuations in commodity prices induce fluctuations in real national income and pose problems in macroeconomic management (Deaton and Miller, 1995). To avoid such problems, several natural-resource-exporting countries created resource windfall funds. According to Stevens (2003), such funds can fulfill three functions. They can be used to insulate the economy from large revenue windfalls by investing them outside the domestic economy. They can play the role of stabilization funds by setting a price assumption for budgetary purposes. If world price exceeds this price, the fund

absorbs the windfalls. If the prices are lower, then the funds' assets are used to top off the budget. Finally, the funds can be used to put assets aside for future generations. Chad (which recently started exporting oil) has created, in an agreement signed with the World Bank, an oil fund for future generations. The fund would have allowed Chad's future generations to enjoy the oil bonanza in the event that the oil reserve is exhausted. However, Chad's government has backed away from the agreement, citing the fact that it needs the money for current problems that the country faces.

5. The fifth policy option is to use an investment policy that will help prevent or limit the effect of Dutch disease. For example, in a policy comparison between Indonesia and Mexico, Usui (1998) found that Mexico's public investment was biased toward the oil sector and that during the oil boom, the Mexican government spent most of the oil revenue in promoting oil production. The Indonesian government, however, biased investment towards the agricultural sector, mainly research and development, investment in irrigation, and subsidization of fertilizer.
6. The last policy option for avoiding the resource curse is to promote good governance. Empirical studies have shown that countries that are less democratic tend to suffer more from the resource curse. Also, countries with weaker institutions are more likely to suffer from corruption. Bulte et al. (2005) found that the impact of resources on development is mainly indirect, occurring through channels of institutional quality.

CONCLUSION

The literature on the resource curse has grown recently due to the poor economic performance of resource-abundant countries. Many explanations have been given for this poor economic performance. They range from poor macroeconomic policy and weaker institutions to trade policy and corruptions.

Although, some policy advice on how the resource curse can be avoided has been given by various authors, only a few tested these policies in a general equilibrium setting. Using a computable general equilibrium model for Chad, Levy (2007) investigated the role of public investment in irrigation and road infrastructure in preventing Dutch disease. She found that public investment tends to improve household wellbeing and economic growth. Andersen and Faris (2002) used a CGE model to analyze the effect in Bolivia of using stabilization funds to reduce fiscal revenue volatility due to fluctuations in oil prices. Their main finding is that keeping the excess funds outside the country will help prevent Dutch disease. The following study proposes the use of uranium revenues in Niger for public investment in infrastructure and human capital.

CHAPTER IV

A DYNAMIC RECURSUVE CGE MODEL FOR NIGER

INTRODUCTION

CGE models incorporate the fundamental general equilibrium links among production structure, incomes of various groups, and patterns of demand (Dervis et al., 1982 p. 133). Although many models are built for policy analysis (Econometric models, Input-output models, Linear programming models), CGE models have some key attractive features that make them very popular. For example, econometric models require long time-series data. However, in developing countries like Niger, long time-series data are not available. Moreover, econometric studies are biased more toward partial equilibrium than general equilibrium. Indeed, partial equilibrium models look at only the impact of economic policy on one market in an economy, thereby ignoring the interdependence among markets. As for input-output models, Partridge and Rickman (2007) note that they lack an explicit economic structure, which makes them unattractive for policy use. Dervis et al. (1982) noted that both input-output models and linear programming models fail to incorporate a situation where economic agents independently maximize their own welfare and policy makers can only affect economic agent decisions indirectly.

The following chapter presents the features of a recursive dynamic computable general equilibrium model (CGE) for Niger and the data used to calibrate the model.

SOCIAL ACCOUNTING MATRIX OF NIGER

A social accounting matrix (SAM) provides the most important data to calibrate CGE models. A SAM represents a snap shot of an economy during a particular period, usually a year. It incorporates the input-output framework of inter-industry relationships and the “income equals expenditures” identities of the national income accounts. That is, data on production, consumption, investment, and trade and income distribution are presented in such way that the SAM replicates the circular flow of income and expenditures in a given year.

A 2004 SAM for Niger obtained from the National Institute of Statistics is used for this study. The SAM, prepared by the World Bank, combines the latest input-output data, household survey data, and other economic data. The SAM project was financed by the Belgium government under the Belgium Poverty Reduction Partnership (BPRP). Table 3 shows the structure of Niger’s SAM. The SAM distinguishes between commodities accounts and activities accounts. The activities accounts include the entities that carry out production. The marketed output and home-consumed output sum to “activities income,” which is priced at producer prices. The commodities accounts include final goods which can be consumed locally by households, business, and government or exported to the rest of the world.

Table 3: Basic Structure of Niger SAM (2004)

	Activities	Commodities	Factors	Household	Government	Direct Tax
Activities		Marketed Output		Home-Consumed Outputs		
Commodities	Intermediate Input			Private Consumption	Government Consumption	
Factors	Value-Added					
Household			Factor Income to Household		Transfers to Household	
Government						Direct Taxes
Direct Tax				Transfer to Government		
Production Tax	Value Added Tax					
Import Tax		Tariffs				
Export Tax		Export Taxes				
Other Tax		Other Taxes				
Saving				Household Savings	Government Savings	
ROW		Imports	Wages to ROW		Government Transfer to ROW	
Total	Activity Expenditure	Supply	Factor Expenditures	Household Expenditures	Government Expenditure	

Table 3: (continued)

	Production Tax	Import Tax	Export Tax	Other Tax	Investment	ROW	Total
Activities							Activities Income
Commodities					Investment	Export	Demand
Factors							Factor Income
Household						Remittance	Household Income
Government	Production Taxes	Import Taxes	Export Taxes	Other taxes		Remittance	Government Income
Direct Tax							
Production Tax							
Import Tax							
Export Tax							
Other Tax							
Saving						Foreign Savings	Total Savings
ROW							Foreign Exchange Outflow
Total					Total Investment	Foreign Exchange Inflow	

There are nine activities and commodities in the SAM: rural, mining, manufacturing, utilities, construction, commerce, transport and telecommunication, financial services, and other services. The rural sector incorporates agriculture, livestock, fishery, and forestry activities. The manufacturing sector includes food and beverage industries, textiles industries, chemical and metal industries, and other manufacturing activities. The commerce sector is composed of privately owned enterprises like small shops, restaurants, and hotels. Other services include public administration, education, health, and community services. The SAM does not distinguish between informal and formal sectors.[5] However, most of the sectors listed above (especially the agricultural, transport, and commerce sectors) contain a combination of formal and informal activities. This is worth mentioning because, like in many developing countries, the informal sectors represent a large share of the economic activity in Niger.

There are two factors of production: labor and capital. Labor is further divided into skilled and unskilled labor.

Six domestic institutions are distinguished in the SAM: five household groups and the government. The household groups are differentiated according to skills and sectors of activity. The five household groups are agricultural, skilled, unskilled, informal, and capitalist. Agricultural households engage in activities such as farming, livestock, and fisheries. They live primarily in rural areas. Informal households are employed in the informal sector and live mostly in urban areas. Capitalist households are households with mixed income; they receive wages and interest. Skilled households are households whose

[5] The concept of the informal sector was introduced into international usage in 1972 by the International Labor Organization (ILO) in its Kenya Mission Report, which defined informality as a “way of doing things characterized by (a) ease of entry; (b) reliance on indigenous resources; (c) family ownership; (d) small scale operations; (e) labor intensive and adaptive technology; (e) skills acquired outside of the formal sector; (g) unregulated and competitive markets.”

members have at least ten years of education; they primarily work in the formal sector and live in urban areas. Unskilled households are households whose members have zero to nine years of education and work in the formal sector.

In addition the SAM explicitly accounts for the following types of taxes: direct taxes, production taxes, import taxes, export taxes, and other taxes. Government income is the sum of these taxes plus foreign remittances.

MODEL EQUATIONS

The Niger CGE model comprises a system of linear and non-linear equations. The specification of the model follows closely the model developed by Dervis et al. (1982), Robinson et al. (1999), and Lofgren et al. (2002). The model is based on two important principles of economics: optimization and equilibrium. It describes the behavior of economic agents, the constraints they face, and the equilibrium conditions in various markets. The equations of the model are presented in the following order: supply, price, income, expenditure, investment dynamic, and market equilibrium and closure.

Supply

Table 4 presents the supply equations. The production of domestic goods is represented by a nested production function as described in equations (1) through (3). At the top level, sectoral production (X_{it}) is the sum of value added (VA_{it}) and demand for intermediate inputs (V_{it}), equation (1). Value added is a Cobb-Douglas production function of skilled labor (LS_{it}), unskilled labor (LUS_{it}) and capital (K_{it}) which is assumed fixed in a given period. Intermediate input requirements are fixed according to input-output coefficients (a_{ij}), equations (2) and (3). Producers are assumed to maximize profit. In a competitive market, factors of production are paid the value of their marginal product. Equations (4) and (5) show the implicit demand for skilled and unskilled labor derived from the first order condition of profit maximization. The model solves for average skilled and unskilled wages that clear both types of labor markets in each sector.

Table 4: Supply

(1) $$X_{it} = VA_{it} + V_{it}$$

(2) $$V_{it} = \sum_{j} a_{ij} X_{it}$$

(3) $$VA_{it} = A_{it} LUS_{it}^{\alpha_{1i}} LS_{it}^{\alpha_{2i}} K_{it}^{1-\alpha_{1i}-\alpha_{2i}}$$

(4) $$PV_{it} \alpha_{1i} \frac{X_{it}}{LU_{it}} = WUS_{it}$$

(5) $$PV_{it} \alpha_{21i} \frac{X_{it}}{LS_{it}} = WS_{it}$$

(6) $$X_{it} = A_{ED} \left[\lambda_{ED} E_{it}^{-\rho_{ED}} + (1-\lambda_{ED}) D_{it}^{-\rho_{ED}} \right]^{\frac{-1}{\rho_{ED}}}$$

(7) $$E_{it} = D_{it} \left[\left(\frac{PWE_{it}}{PD_{it}} \right) \left(\frac{1-\lambda_{ed}}{\lambda_{ed}} \right) \right]^{\sigma_{ed}}$$

(8) $$Q_{it} = A_{Q} \left[\lambda_{Q} M_{it}^{-\rho_{Q}} + (1-\lambda_{Q}) D_{it}^{-\rho_{Q}} \right]^{\frac{-1}{\rho_{Q}}}$$

(9) $$M_{it} = D_{it} \left[\left(\frac{PM_{it}}{PD_{it}} \right) \left(\frac{1-\lambda_{Q}}{\lambda_{Q}} \right) \right]^{\sigma_{Q}}$$

Equations (6) through (9) describe the international trade part of the model. The small country assumption holds for Niger's economy. Equation (6) shows the constant elasticity of transformation (CET) between the quantity of production that is exported and the quantity that is sold domestically. Producers maximize revenue from sales subject to the CET function. The first order condition is represented in equation (7), the export supply function which depends on relative prices ($\frac{PWE_{it}}{PD_{it}}$), where (PWE_{it}) is the world price of export and (PD_{it}) is the domestic prices, on share parameters (λ_{ed}), and on transformation elasticity (ρ_{ed}). The so called Armington (1969) aggregation function for composite goods is presented in equation (8). It shows an imperfect substitutability between imported goods and domestically produced goods. Consumers minimize the cost of acquiring the composite goods subject to imperfect substitutability.

Prices

Table 5 shows the price equations. The first order condition of cost minimization yields to equation (9), which is the import demand equation. Import demand depends on relative prices ($\frac{PM_{it}}{PD_{it}}$), where PM_{it} is the price of import, on share parameters (λ_Q), and on the Armington substitution parameters (σ_Q).

Table 5: Prices

(10) $$PM_{it} = \overline{pw_i}(1 + tm_i)ER$$

(11) $$PWE_{it} = \frac{PD_{it}}{(1 + te_i)ER}$$

(12) $$PQ_{it} = \frac{[PM_{it} M_{it} + D_{it} PD_{it}]}{Q_{it}}$$

(13) $$PV_{it} = PD_{it}(1 - tau) - \sum_j PQ_{jt} a_{ij}$$

(14) $$CPI_{it} = \sum_{i=1}^{n} fc_i PQ_{it}$$

Table 5 above shows the price equations. Equation (10) defines the price of imports. The world price ($\overline{pw_i}$), expressed in dollars, is exogenous due to the small country assumption for Niger. The domestic price of imports is equal to the world price of imports times one plus the import tariffs (tm_{it}) times the exchange rate (ER). The export price equation (11), is the domestic price divided by 1 plus the export subsidy (which is zero in Niger) times the exchange rate. Equation (12) describes the price of composite good Q (PQ_{it}) which is a CES aggregation function of domestic (D) and import (M) goods supplied to the domestic market. Equation (13) defines the value-added prices or net-prices (PV_{it}), which are equal to the domestic price minus unit indirect taxes (tau) and the unit cost of intermediate inputs (based on the fixed input-output coefficients). Finally, equation (14) shows the consumer price index (CPI_{it}), which is equal to the weighted sum of composite prices, where the weight is the share (fc_i) of each commodity in total consumption.

Income and Saving

Equations (15) and (16) in Table 6 describe the wages for skilled and unskilled labor. The wage for skilled labor (YLS_t) is equal to the sum across sectors of the wage rate times the amount of labor in each sector. The wage for unskilled labor ($YLUS_t$) is calculated similarly. Capital income (YK_t) in equation (17) is the residual after subtracting the wages from the value added. Equation (18) shows household disposable income ($Hinc_{it}$). Household income is composed of wages and profit received from labor services and capital investment, government transfers ($\overline{GTH}$), and remittances received from abroad ($\overline{WTH}$).

Table 6: Income and Saving Equations

(15) $YLS_t = \sum_i WS_{it} LS_{it}$

(16) $YLUS_t = \sum_i WUS_{it} LUS_{it}$

(17) $YK_i = \sum_i \left(PV_{it} VA_{it} - WS_{it} LS_{it} - WUS_{it} LUS_{it} \right)$

(18) $Hinc_{ht} = (YLS_t HFSH_1 + YLUS_t HFSH_2 + YK_t HFSH_3 + \overline{WTH} * ER + \overline{GTH}) * (1-t)$

(19) $YG_t = \sum_h Hinc_h * t + \sum_i X_{it} * tau_i + \sum_i M_{it} * tm + \sum_i X_{it} * tex + \overline{WTG} * ER$

(20) $GDP_t = YLS_t + YLUS_t + YK_t + YG_t - (Fsav_t - \overline{WTG} - \overline{WTH}) * ER$

(21) $RGDP_t = \dfrac{GDP_t}{CPI}$

(22) $Exp\inf_t = {}^{100*\left(CPI - CPI_o\right)}\!\Big/\!{}_{CPI_o}$

(23) $R_t = No\min t_t - Exp\inf_t$

(24) $Hsav_{ht} = MPS_H * Hinc_H$

(25) $GS_t = YG_t - G\exp_t$

(26) $TS_t = \sum_h Hinc_{ht} + GS_t + Fsav_t * ER$

Households pay income taxes, which are added to government income (YG_{it}) in equation (19). In addition to household income taxes, the government collects indirect taxes (or value-added taxes), import tariffs, and export taxes, which are included in equation (19).

Finally, the Government receives remittances from abroad in the form of grants or no-interest loans ($\overline{WTG}$).

Then nominal GDP in equation (20) is defined as the sum of skilled and unskilled wages, capital income, and government income minus foreign saving ($Fsav_t$) and the remittances received by both the government ($\overline{WTG}$) and the households ($\overline{WTH}$). Real GDP in equation (21) is obtained by dividing the nominal GDP by the consumer price index. The percentage change in the consumer price index is equal to the inflation rate ($Exp\inf_t$) as given in equation (22). The real interest rate (R_t) in equation (23) is obtained by subtracting the rate of inflation from the nominal interest rate.

Equation (24) shows that household savings ($Hsav_t$) is equal to household income times the marginal propensity to save (MPS_h). Government savings (GS_t) in equation (25) is equal to government income minus government expenditures. Equation (26) shows total savings (TS_t). It is equal to household savings plus government saving plus foreign savings, which is assumed endogenous.

Expenditure Equations

Table 7 shows the expenditure equations, which are household consumption demand (equation 27), government consumption (equation 28), total consumption (equation 29), and government expenditures (equation 30). The household consumption demand function ($CH_{it,h}$) is given by a linear expenditure system (as shown in equation

27) derived from the Stone-Geary utility function[6], where, $\gamma_{i,h}$ are the committed expenditures or the "subsistence minima"[7] and the term $\left[\left(Hinc_{t,h} - Hsav_{t,h}\right) - \sum_j PQ_j \gamma_{j,h}\right]$ is known as "uncommitted" or "supernumerary" income, which is spent in fixed proportions $\beta_{i,h}$ between the commodities. $\beta_{i,h}$ are the marginal budget shares. The marginal budget shares determine the allocation of the income that remains after satisfying the "substance minima." It tells how expenditures on each commodity change as income changes. Since $1 \succ \beta_i \succ 0$, the linear expenditures system does not allow for inferior goods.

Table 7: Expenditure Equations

(27) $$CH_{it,h} = \gamma_{it,h} + \frac{\beta_{i,h}}{PQ_{it}}\left[\left(Hinc_{t,h} - Hsav_{t,h}\right) - \sum_j PQ_j \gamma_{j,h}\right]$$

(28) $$Gcom_{it} = \frac{gcfc_i * GC_{it}}{PQ_{it}}$$

(29) $$TC_{it} = \sum_h CH_{it,h} + Gcom_{it}$$

(30) $$G\exp_t = \sum_i PQ_{it} Gcom_{it} + GTH * CPI + GTW * ER$$

6 The Stone-Geary utility function takes the forms: $U = \prod_i (x_i - \gamma_i)^{\beta_i}$ where γ_i represent the subsistence requirement for good x_i, $1 \succ \beta_i \succ 0$ and $\sum \beta_i = 1$. The Stone-Geary utility function collapses to a Cobb-Douglas utility function when γ_i =0.

7 Subsistence expenditures are defined as the minimum household expenditure on a particular food commodity or group of commodities.

Government demand for final goods ($Gcom_{it}$) is defined as fixed shares ($gcfc_i$) of aggregate real government spending on goods and services (GC_{it}). Total consumption (TC_{it}) is the sum of household consumption plus government consumption. Government expenditure ($G\exp_t$) is composed of government consumption, government transfers to households, and government transfers to the rest of the world.

Investment Block

Table 8 shows the investment dynamic equations.

Table 8: Investment Equations

(31) $$Z_{it} = H_{it}\frac{TS_t}{U_{it}}$$

(32) $$Zo_{it} = \sum_j s_{ij} Z_{jt}$$

(33) $$H_{i,t-1} = SP_{i,t-1} + SP_{i,t-1}\left(\frac{R_{i,t-1} - AR_{t-1}}{AR_{t-1}}\right)$$

(34) $$R_{it} = \frac{YK_{it}}{U_{i,t-1}K_{i,t-1}}$$

(35) $$Yk_t = \sum_i Yk_{it}$$

(36) $$SP_{it} = \frac{Yk_{it}}{Yk_t}$$

(37) $$AR_t = \sum_{i=1}^{n} SP_{it} R_{it}$$

(38) $$U_{it} = \sum_{j=1}^{n} s_{ji} PQ_{ji}$$

(39) $$K_{i,t+1} = K_{0,it} + Z_{it}$$

Aggregate investment in equation (31) is equal to total saving in the economy plus foreign savings. Moreover, aggregate investment is divided into two parts: investment by sector of destination and investment by sector of origin. Equation (31) describes investment by sector of destination (Z_{it}), which is equal to investment shares (H_{it}) times the total savings divided by a vector of capital prices (U_{it}). Investment by sector of origin (Zo_{it}) is derived from investment by sector of destination by using the capital composition matrix (s_{ij})[8] as illustrated in equation (32).

Sectoral investment share ($H_{i,t-1}$) is a function of the sectoral share of aggregate profit (Sp_{it}) and the profit rate differential ($\left(\frac{R_{i,t-1} - AR_{t-1}}{AR_{t-1}}\right)$) as illustrated in equation (33). Aggregate profit share is the ratio of profit in sector i to the total sectoral profit as described in equation (36). The sectoral profit rate (R_{it}), as illustrated in equation (34), is equal to the return to capital. Equation (37) shows the average nominal profit rate (AR_{it}), which is a weighted sum of the profit rate using the sectoral share of aggregate profit as the weight. The price of capital (U_{it}) in equation (38) is a weighted sum of the composite price and capital composition matrix. Finally, the next period capital stock ($K_{i,t+1}$) in equation (39) is equal to the initial capital stock plus investment by sector of destination.

Income Distribution and Welfare Measures

There are many measures of income inequality. The most commonly used are the Gini coefficient, the Theil index, the Atkinson's index, and the coefficient of variations.

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[8] The capital composition matrix is composed of coefficients describing the make-up of sectoral capital stock.

The Gini coefficient is the most popular measure of income inequality[9]. It allows one to examine the change in income distribution of households. The Gini coefficient ranges from 0 to 1. When the Gini coefficient is equal to 0, income is equally distributed among households, a condition known as perfect equality. A Gini coefficient of 1 represents a situation where all the incomes are held by one household group, referred to perfect inequality.

Table 9 shows the Gini coefficient and equivalent variation equations. To capture the effect of different policy scenarios on income inequality, the present study uses the Gini coefficient as a measure of inequality (equation 40). The present model uses representative household groups with the assumption of income homogeneity in each household group. Therefore, the Gini coefficient computed in this study measures the inequality across the five representative household groups.

Table 9: Gini Coefficient and Equivalent Variation Equations

(40) $$Gini = \frac{1}{2n^2 Hincbar} \sum_i \sum_j \left| Hinc_i - Hinc_j \right|$$

(41) $$EV_{ht} = \prod_i \frac{PQ_{o,it}}{PQ_{it}} Hinc_h - Hinc_{o,h}$$

Policy analysts often refer to welfare indicators to evaluate the impact of a policy change. The most commonly used of welfare indicators are the consumer surplus, the compensating variation, and the equivalent variation. The consumer surplus is used mostly in cases where the price of only one good changes. It is also very easy to compute. However, the consumer surplus is not well defined when there are multiple price changes or a simultaneous change in income and price. The compensating variation (CV) and the

[9] Cowell (1998) has an excellent overview of the pros and cons of each of these measures.

equivalent variation (EV) do not suffer from this shortfall, which makes them very attractive. CV is the amount of money which, when taken away from the consumer after the price change and income change, leaves him with the same level of utility as before the change. EV is the amount of money which, when paid to the consumer, achieves the same level of utility before the change that would be enjoyed with the economic change.

To gauge the impact of the simulations on the welfare of each representative household group, equivalent variations (a measure commonly used in CGE models) were computed as shown in equation 41. The equivalent variation is a function of initial income and initial composite prices ($Hinc_{o,h}, PQ_{o,it}$) and the new income and new composite prices ($Hinc_{h}, PQ_{it}$).

Market Clearing Conditions and Macroeconomic Closure

Table 10 presents the market clearing conditions. Indeed, for the model to be complete, it must satisfy a system of constraints: supply-demand equilibrium conditions and the macroeconomic closure rule. Equation (42) shows the equilibrium condition in the product markets. In a competitive market, prices adjust to clear the factor and product markets. The equation states that the supply of each composite good must equal its demand. Domestic prices (PD_{it}) adjust to bring about equilibrium in the market for each good.

Table 10: Market Clearing Condition and Macroeconomic Closure

(42) $Q_{it} = INT_{it} + CH_{it,h} + Gcom_{it} + Z_{it}$

(43) $LUS_{it}^{D} = LUS_{it}^{S}$

(44) $LS_{it}^{D} = LS_{it}^{S}$

(45) $Fsav_{t} = \sum_{i} PM_{it} M_{it} - \sum_{i} PWE_{it} E_{it}$

(46) $TS_{t} = \sum_{i} Z_{it}$

Equations (43) and (44) state that the supply of skilled and unskilled labor equals their respective demand. The average skilled and unskilled wage rates adjust to clear the skilled and unskilled labor market. Capital is assumed fixed in each sector during the current year.

Equations (45) and (46) describe macroeconomic equilibrium conditions for the balance of payments and saving-investment balances. Niger has a fixed exchange rate, so the choice of foreign exchange market closure is important. Equation (45) shows that foreign capital inflow ($Fsav_{t}$) is equal to the difference between total imports and total exports. With a fixed exchange rate, foreign capital inflow will have to adjust to bring the balance of payments in equilibrium. Equation (46) describes neoclassical closure, where aggregate saving is equal to total investment.

DATA AND CALIBRATION

The next step in building most CGE models is to calibrate the equations using data for one period. Although one could use econometric techniques to estimate some of the parameters, the lack of data makes this an elusive quest. Like most CGE models, this model utilizes the information contained in the SAM to calibrate most of the parameters. The parameters that could not be calibrated using Niger's SAM were borrowed from other studies.

As mentioned earlier, a 2004 SAM was obtained from the National Institute of Statistics. The CGE model must satisfy the various identities included in the SAM. In fact, calibration involves a process of finding a set of parameters and exogenous variables so the CGE model replicates data contained in the SAM.[10] For example, the following parameters were calibrated using the data in the SAM: the share of unskilled and skilled labor (α_{1i}, α_{2i}) in production, the technology factor (A_i), and the marginal propensity to save (MPS) for each of the representative household groups.

The imports and exports are represented by CES functions. The three unknown parameters for a typical CES function are the shift parameter (A), the share parameter (λ), and the elasticity parameter (ρ). Following tradition in CGE modeling, the trade elasticity parameters were borrowed from Decaluwe et al. (2004). These elasticities were then used along with the information contained in the SAM to calibrate the shift and share parameters. For example, the share parameter (λ_Q) and the shift parameter (A_Q) of composite goods are calibrated by respectively solving for λ_Q in equation (9) and A_Q in equation (8) as illustrated in equations (47) and (48).

$$\lambda_Q = \frac{\left(\frac{PM_i}{PD_i}\right)\left(\frac{M_i}{D_i}\right)^{\frac{1}{\sigma_Q}}}{1+\left(\frac{PM_i}{PD_i}\right)\left(\frac{M_i}{D_i}\right)^{\frac{1}{\sigma_Q}}} \qquad (47)$$

[10] For more discussion on CGE calibration processes see Robinson et al. (1999).

$$A_Q = \frac{Q_i}{\left[\lambda_Q M_{it}^{-\rho_Q} + (1-\lambda_Q) D_{it}^{-\rho_Q}\right]^{\frac{-1}{\rho_Q}}} \qquad (48)$$

The parameters of the export function are calibrated in a similar fashion.

As mentioned earlier, the household consumption function is represented by a linear expenditure system. The CGE model requires full specification of the linear expenditure system (LES). The calibration of LES involves the use of exogenous parameters: the “substance minima” and the marginal budget share. These parameters can either be estimated (if data are available) or borrowed from the literature.

The calibration process for the linear expenditure system starts by computing the average budget shares. These shares are obtained by dividing the consumption expenditures for sector i by the total consumption expenditure. The present study uses exogenously specified income elasticity (η_i) of demand and a parameter measuring the elasticity of marginal utility of income with respect to income (ω), known as the Frisch parameter (Frisch 1959), to compute the LES parameters. The Frisch parameters are given by the following formula:

$$\omega_h = -\left(Hinc_h - Hsav_h\right) \Big/ \left[\left(Hinc_h - Hsav_h\right) - S\right]$$

$$Where \quad S = \sum_j PQ_j \gamma_{j,h} \qquad (49)$$

The income elasticities are given by:

$$\eta_{i,h} = \beta_{i,h} * (Hinc_h - Hsav_h) \Big/ PQ_{it} * CH_{i.h} \qquad (50)$$

The estimates of the Frisch and income elasticities are based on various cross-country studies, especially that of Dervis et al. (1982). With the Frisch and income elasticities parameters estimated, the computation of marginal budget shares and “subsistence minima” is straightforward. The “subsistence minima” (equation 51) is obtained by solving equation (47) and using the information contained in equation (50):

$$\gamma_{i,h} = CH_{i,h} + \left(\sum_i CH_{i,h} * \eta_{i,h} / \omega_h \right) \qquad (51)$$

Manipulating equation (50) yields the formula for computing the marginal budget share, equation (52), as follows:

$$\beta_{i,h} = \eta_{i,h} * PQ_{ij} * C_{i,h} / \left(Hinc_h - Hsav_h \right) \qquad (52)$$

CONCLUSION

Chapter V discusses the key structure of Niger’s CGE model, which is a standard one. However the model incorporates a dynamic investment equation, an additional component not usually found in traditional CGE models. In addition, household consumption is modeled using a linear expenditure system. The chapter also presents the structure of Niger’s SAM, which contains most of the data used to calibrate the model. Indeed, exogenous parameters are also used to calibrate the model; for example the calibration of LES involved the use of Frisch parameters and income elasticity.

CHAPTER V

THE IMPACT OF A NATURAL RESOURCE WINDFALL

INTRODUCTION

The present chapter analyzes the impact of a natural resource windfall on Niger's economy. The idea is to quantify the impact on selected variables, namely real GDP, household income, consumption and welfare, consumer price index (CPI), and income inequality (as measured by the Gini coefficient).

The impact of foreign capital in the form of aid or a natural resource windfall has drawn the attention of many economists due to the potential of Dutch disease effects (Corden and Neary, 1982). However, only a few authors quantify the effect of a natural resource windfall on an economy using a CGE model of developing countries: Benjamin et al. (1989), Benjamin (1990), and Robinson et al. (1999). For example, Benjamin (1990) used a two-period CGE model to quantify the oil windfall in the Cameroon economy. Her major finding is that the manufacturing sector is likely to contract in the short term because of the inflow of capital but to expand in the long run. The major drawback of these earlier studies is their neglect of the distributional and welfare impact of a natural resource windfall.

The present study differs from the previous literature in two ways. First, a dynamic computable general equilibrium model is used to quantity the effect of the inflow of capital. Second, past studies focused only on the macroeconomic impact of the windfall whereas this study, in addition to the macroeconomic impact, looks at the distributional and welfare impact of a natural resource windfall.

The model is first run for twelve years, from 2004 to 2015, with the assumption that there is no natural resource windfall (the Baseline Scenario), and then the model is used to simulate the impact of the windfall (Simulation I). In Simulation I, the economy is injected with 78.54[11] billions of CFA. The objective in Simulation I is to mimic the current government policy, which consists of distributing part of the windfall revenue to households and spending the rest. The government is assumed to seize 1/3 of the amount and transfer 2/3 to each representative household group according to a transfer parameter computed using the information contained in the SAM.

This chapter is divided as follows. First, the baseline results are compared with Simulation I to see the impact on the key macroeconomic variables (real GDP, Saving, CPI), and then the impact on household welfare and income inequality.

THE IMPACT OF THE WINDFALL ON KEY MACROECONOMIC VARIABLES

Table 11 summarizes the impact of the experiment on selected macroeconomic variables.

[11] This is the exact amount that Niger's government received from exporting uranium in 2005.

Table 11: Macroeconomic Impact of Natural Resource Windfall

	2005	2006	2007	2008	2009	2010
Real GDP	0.20%	4.15%	10.85%	12.08%	11.71%	13.16%
CPI	0.10%	2.76%	9.38%	9.74%	10.15%	13.66%
Nominal Wages	0.19%	18.69%	62.55%	67.87%	67.04%	86.11%
Government Income	0.03%	3.72%	12.31%	13.63%	14.68%	19.54%
Capital Income	11.92%	23.98%	54.33%	57.68%	57.30%	71.47%
Private Saving	1.30%	36.04%	120.86%	130.68%	123.00%	152.77%
Public Saving	364.60%	243.17%	491.55%	431.20%	311.18%	316.64%
Total Saving	8.75%	39.66%	116.78%	124.69%	117.45%	144.45%
Total Investment	8.74%	38.93%	106.06%	94.87%	84.41%	108.07%
Export	2.53%	14.27%	41.43%	42.43%	41.79%	54.52%
Import	2.67%	13.99%	40.75%	43.10%	43.11%	55.87%
Sectoral Production	3.25%	14.92%	42.55%	43.62%	43.21%	56.47%

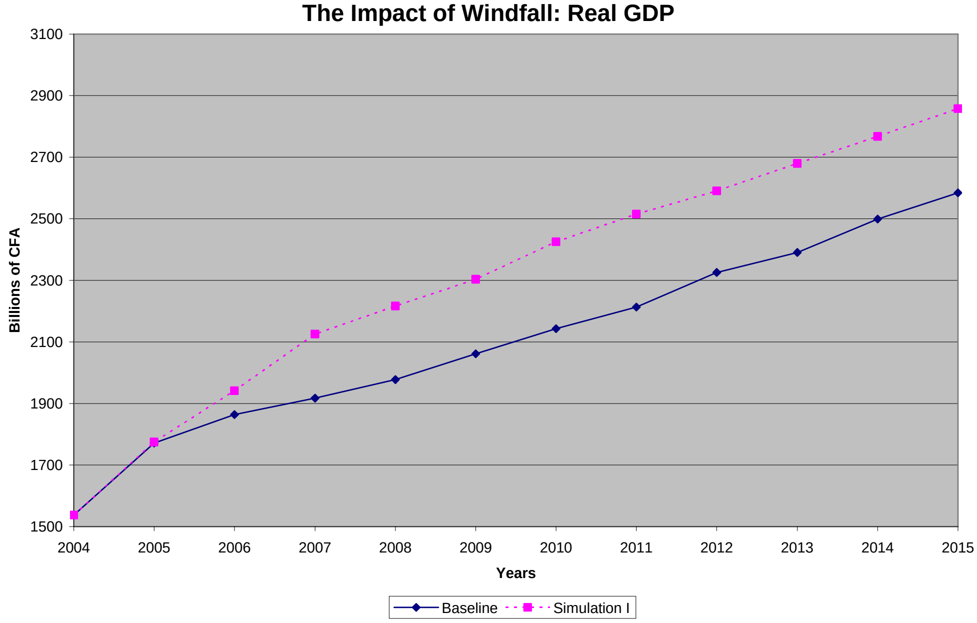
Table 11 (continued)

	2011	2012	2013	2014	2015
Real GDP	13.65%	11.40%	12.07%	10.73%	10.57%
CPI	14.59%	12.62%	14.15%	13.34%	14.09%
Nominal Wages	91.49%	73.17%	81.81%	72.52%	74.01%
Government Income	21.15%	18.84%	21.05%	20.12%	21.07%
Capital Income	75.50%	62.75%	69.54%	63.07%	64.58%
Private Saving	160.26%	119.14%	133.47%	112.12%	112.32%
Public Saving	299.71%	194.41%	207.09%	159.94%	152.59%
Total Saving	150.78%	113.62%	126.49%	107.09%	107.25%
Total Investment	107.19%	75.77%	91.13%	74.00%	75.64%
Export	57.22%	46.43%	52.99%	47.65%	49.36%
Import	59.17%	48.79%	54.88%	49.79%	51.38%
Sectoral Production	59.37%	48.53%	55.05%	49.69%	51.30%

Real GDP increases in Simulation I relative to the baseline as a result of the natural resource windfall. On average, real GDP changes from the baseline by 10 percentage points, which indicates that the windfall is growth promoting. Figure 3 shows the dynamic path of real GDP. The natural resource windfall widens the real GDP gap between the baseline and Simulation I. This is an important finding because contrary to the natural resource curse hypothesis, this windfall improved real GDP.

The increase in real GDP is primarily due to an increase in the total amount of savings available in the economy. Indeed, the assumption in Simulation I is that 1/3 of the windfall is seized by the government. Furthermore, government consumption is held constant, which means that additional revenue collected by the government is saved rather than consumed. As a result, public savings more than tripled in 2005, following the windfall. Private savings also increased drastically from the baseline because households receive 2/3 of the windfall from the government. The government transfer increases household income, which translates into higher savings given a fixed marginal propensity to save.

Figure 3
The Impact of Windfall: Real GDP



In addition, total nominal wages (Figure 5) increase, which also increases household income and therefore increases the level of household savings. Figure 4 shows the dynamic path of total saving. After a small jump in 2005, total saving increased significantly compared to the baseline scenario.

The increase in total nominal wages is due to two main factors. First, the model is a full employment model, meaning there is no unemployment. The wage rate adjusts to equate the supply and demand for labor. The demand for labor increases as the capital available for producers increases. This creates an upward pressure on wages. Second, the value-added price results in higher nominal wages.

Figure 4
The Impact of Windfall: Total Saving

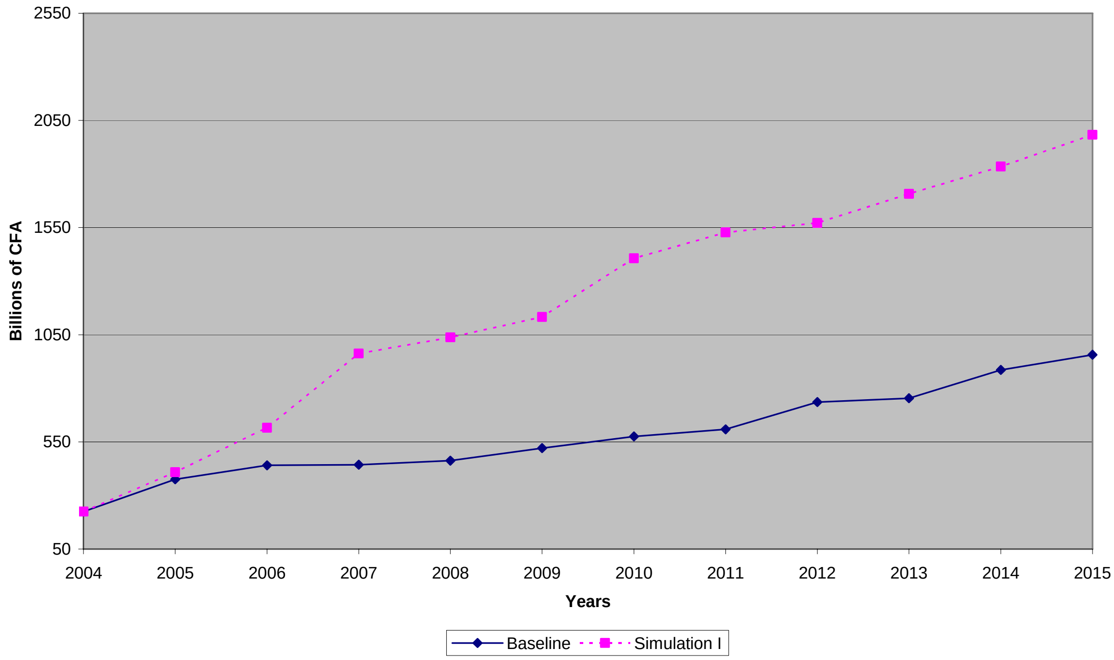


Figure 5
The Impact of Windfall: Total Nominal Wage

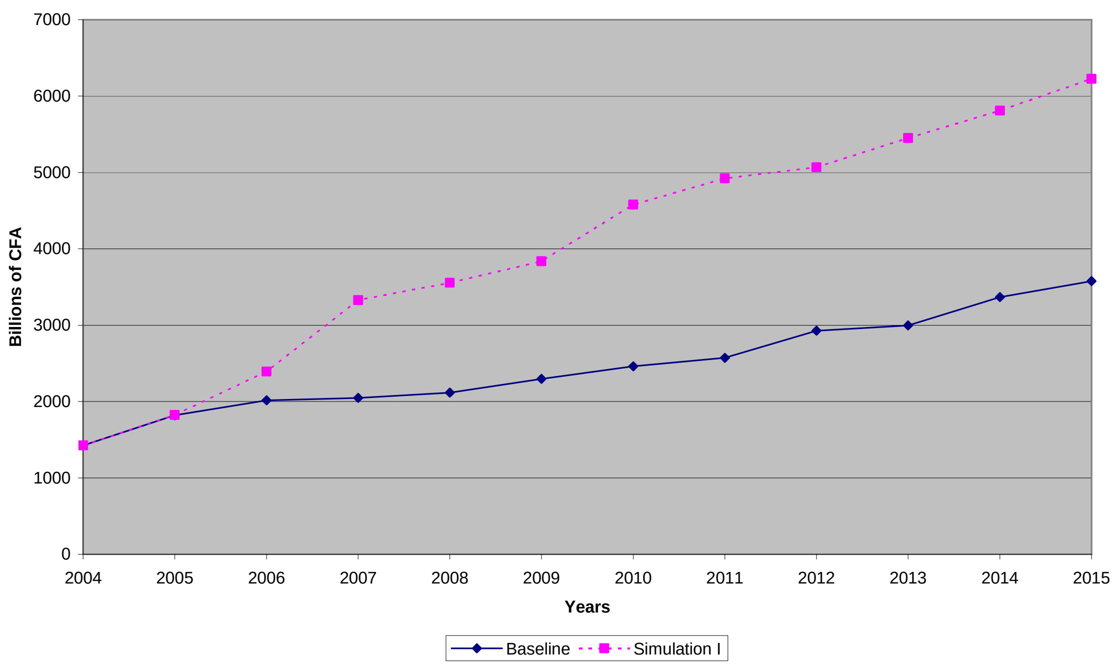
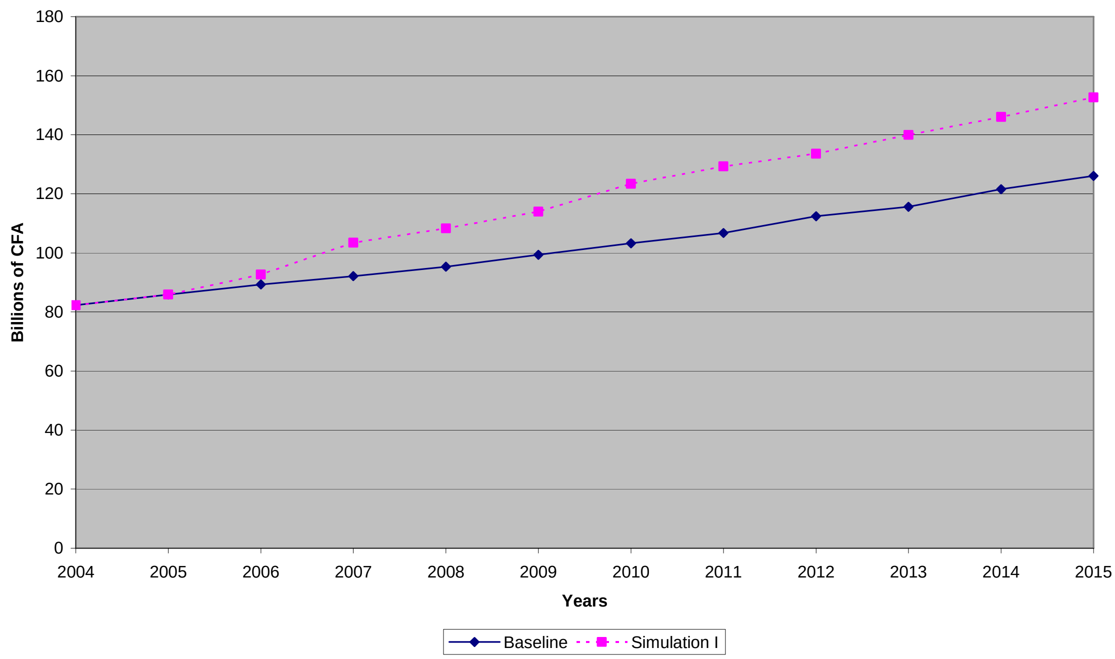


Figure 6 presents the dynamic path of capital income.

Figure 6
The Impact of Windfall: Capital Income



As one would expect, the increase in saving translates into an increase in total real investment in the economy as shown in Figure 7. For example, total real investment increases by 75% in 2015 compared to the baseline. Total sectoral profit as measured by capital income (Figure 6) also increases as a result of the windfall.

The increase in economic activities due to the inflow of natural resource revenue results in a rise in the average level of prices compared to the baseline scenario. The consumer price index (CPI) increases; further, the difference increases so that the rate of inflation[12] increases. Figure 8 shows the dynamic path of the CPI. The gap between the baseline CPI and Simulation I CPI increases. This result confirms the spending effect associated with the Dutch disease hypothesis, which states that an increase in a natural

[12] Since the model does not have a monetary component, inflation in this study is the percentage CPI, which is just the weighted sum of relative composite prices.

resource windfall tends to increase demand for goods and services, thereby increasing relative prices.

Figure 7
The Impact of Windfall: Total Investment

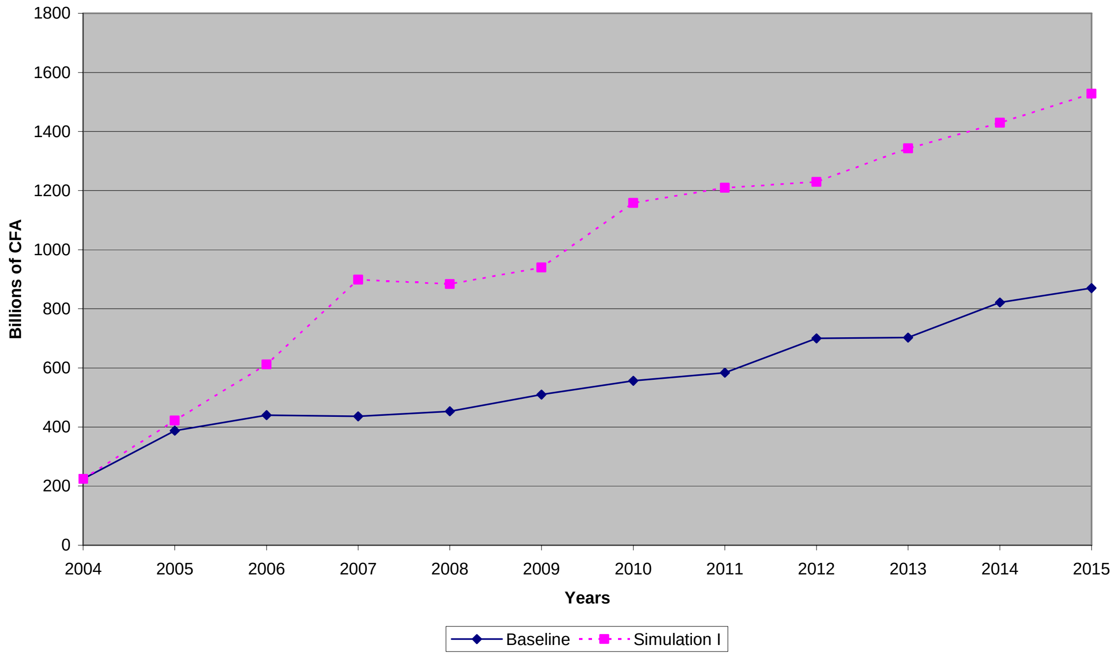
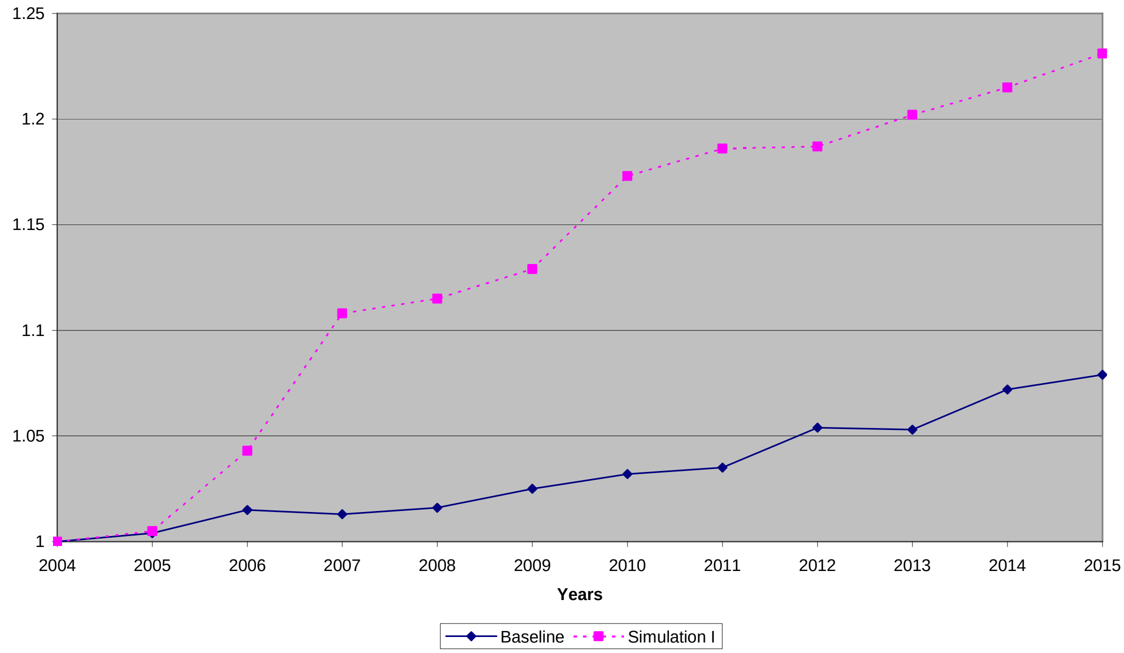


Figure 8
The Impact of Windfall: CPI



HOUSEHOLD WELFARE AND INCOME DISTRIBUTION

The objective of this section is to analyze the impact of a natural resource windfall on household welfare and income distribution in Niger. There are five representative household groups in the model. Tables 12 and 13 summarize the impact of a natural resource windfall on each representative household income and real consumption respectively.

Table 12 shows that household incomes improve significantly. This increase can be explained by the fact that in Simulation I the government transfers 2/3 of the windfall to the households. Furthermore, the increase in nominal wages and capital income mentioned earlier contribute to the significant increase in household income.

However the increase in household income is not evenly distributed across household groups. Figure 9 shows the dynamic path of the Gini coefficient, which indicates raising inequality. The increase in income inequality is primarily due to the relative increase in skilled household income. For example, by the end of 2015 skilled household income increases by 130% compared to only 36% for unskilled household income. The result can not be explained by the share of total government transfer to skilled households, which is relatively small compared to the other household groups. However, the wages received by the skilled households increase dramatically in Simulation I, reflecting the increased productivity of skilled labor. Figures 10 and 11 show the transition path of skilled and unskilled nominal wages. The skilled wages are increasing at a faster rate than the unskilled wages.

Figure 9
The Impact of Windfall: Gini Coefficient

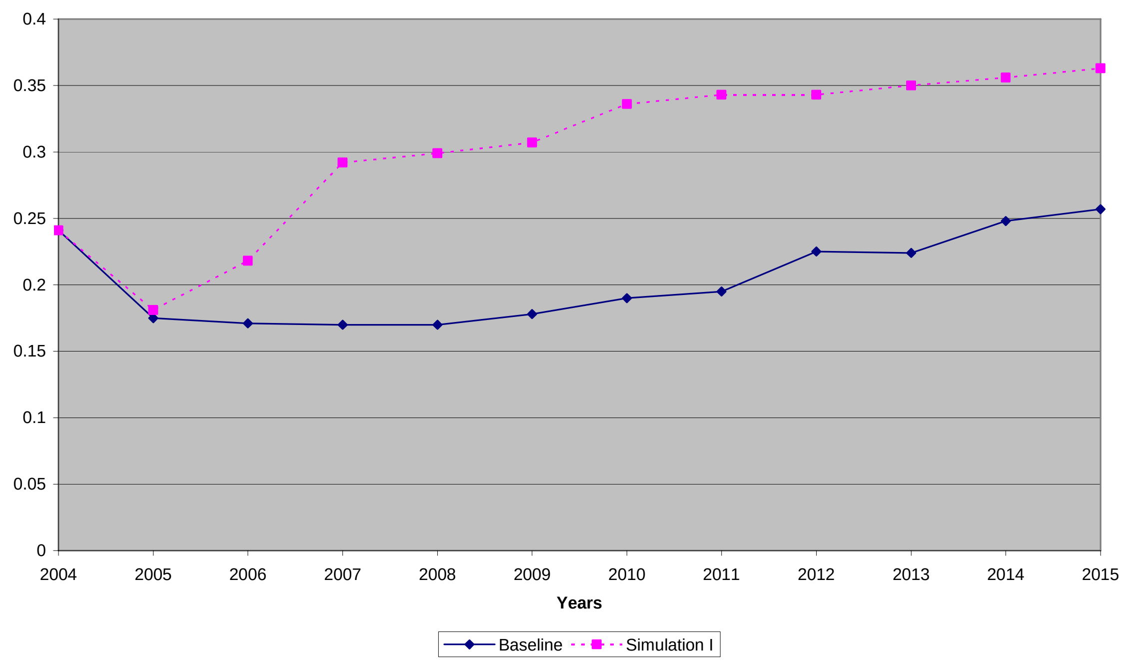


Figure 10
The Impact of Windfall: Skilled Nominal Wage

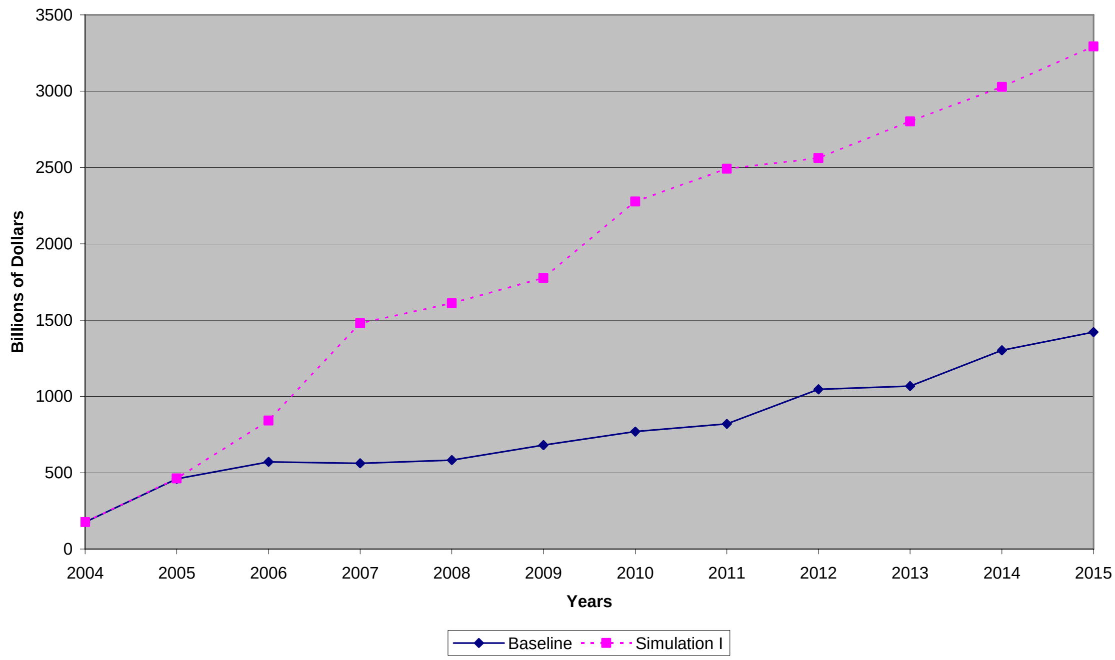


Figure 11
The Impact of Windfall: Unskilled Nominal Wage

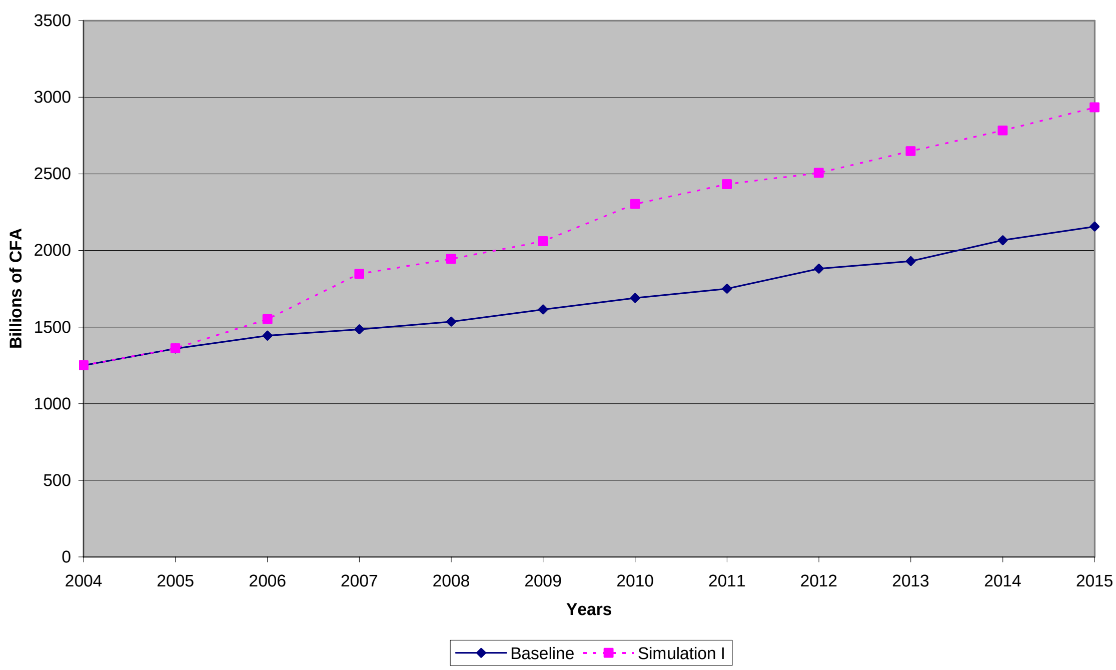


Table 13 presents the effect on household real consumption. The results show that each representative household group experiences an increase in real consumption. Indeed, as household incomes increase, so does household real consumption, holding marginal propensity to consume constant before and after the simulation. Just as household incomes are not evenly distributed, household real consumption also differs across household groups. Skilled households have the highest increase in consumption as opposed to capitalist households. For example, from the baseline to Simulation I, skilled household consumption increases by 128% in 2015 as opposed to 25.80% for capitalist households.

Table 12: Total Household Income

	Agricultural Household			Skilled Household			Unskilled Household		
	Baseline	Simulation I	% Change	Baseline	Simulation I	% Change	Baseline	Simulation I	% Change
2004	469.514	469.514	0.00%	163.255	163.255	0.00%	319.229	319.229	0.00%
2005	508.567	541.218	6.42%	417.673	420.624	0.71%	347.142	350.162	0.87%
2006	538.254	608.202	13.00%	517.129	760.011	46.97%	368.57	398.259	8.06%
2007	552.269	712.714	29.05%	509.459	1332.563	161.56%	378.787	473.191	24.92%
2008	569.973	747.126	31.08%	528.075	1449.751	174.54%	391.634	498.003	27.16%
2009	597.9	787.384	31.69%	616.444	1597.97	159.22%	411.783	527.003	27.98%
2010	624.322	873.167	39.86%	696.372	2046.663	193.90%	430.854	588.543	36.60%
2011	645.542	918.88	42.34%	741.657	2239.344	201.94%	446.207	621.428	39.27%
2012	691.305	945.043	36.70%	944.045	2302.373	143.88%	479.109	640.34	33.65%
2013	708.65	994.689	40.36%	963.112	2518.109	161.46%	491.693	676.039	37.49%
2014	756.298	1042.04	37.78%	1173.617	2720.468	131.80%	525.951	710.097	35.01%
2015	787.932	1095.074	38.98%	1281.34	2958.062	130.86%	548.758	748.219	36.35%

Table 12 (continued)

	Informal Household			Capitalist Household		
	Baseline	Simulation I	% Change	Baseline	Simulation I	% Change
2004	434.379	434.379	0.00%	144.134	144.134	0.00%
2005	473.077	481.803	1.84%	156.244	164.056	5.00%
2006	502.314	547.993	9.09%	164.819	184.012	11.64%
2007	516.004	651.343	26.23%	169.185	215.999	27.67%
2008	533.354	685.229	28.48%	174.773	226.719	29.72%
2009	560.84	724.891	29.25%	183.471	239.372	30.47%
2010	586.837	809.676	37.97%	191.712	265.862	38.68%
2011	607.679	854.764	40.66%	198.394	280.09	41.18%
2012	652.834	880.473	34.87%	212.59	288.418	35.67%
2013	669.833	929.451	38.76%	218.101	303.912	39.34%
2014	716.849	976.16	36.17%	232.916	318.682	36.82%
2015	747.998	1028.496	37.50%	242.821	335.201	38.04%

Table 13: Total Real Consumption By Household Group

	Agricultural Household			Skilled Household			Unskilled Household		
	Baseline	Simulation I	% Change	Baseline	Simulation I	% Change	Baseline	Simulation I	% Change
2004	451.257	451.257	0.00%	94.272	94.272	0.00%	277.671	277.671	0.00%
2005	490.272	521.981	6.47%	237.172	238.802	0.69%	306.339	308.983	0.86%
2006	516.636	575.425	11.38%	291.528	423.87	45.40%	324.62	347.89	7.17%
2007	530.394	656.681	23.81%	287.167	735.406	156.09%	333.431	407.361	22.17%
2008	546.482	688.111	25.92%	297.08	800.093	169.32%	344.09	428.778	24.61%
2009	570.296	721.505	26.51%	345.084	879.172	154.77%	360.576	451.887	25.32%
2010	593.438	790.127	33.14%	388.664	1122.22	188.74%	376.47	500.96	33.07%
2011	612.766	830.11	35.47%	413.418	1227.686	196.96%	389.477	528.509	35.70%
2012	650.566	854.331	31.32%	523.25	1261.385	141.07%	416.114	544.478	30.85%
2013	667.563	896.54	34.30%	534.04	1377.807	158.00%	427.27	573.615	34.25%
2014	707.193	937.662	32.59%	648.097	1487.611	129.54%	455.027	601.836	32.26%
2015	735.323	983.234	33.71%	706.876	1616.248	128.65%	474.23	633.22	33.53%

Table 13 (continued)

	Informal Household			Capitalist Household		
	Baseline	Simulation I	% Change	Baseline	Simulation I	% Change
2004	419.095	419.095	0.00%	140.592	140.592	0.00%
2005	466.411	475.017	1.85%	148.543	156.048	5.05%
2006	495.863	539.206	8.74%	154.635	166.82	7.88%
2007	508.906	637.11	25.19%	159.212	183.858	15.48%
2008	525.019	670.686	27.75%	164.219	192.501	17.22%
2009	550.931	706.979	28.32%	170.625	201.711	18.22%
2010	575.813	786.521	36.59%	176.987	217.822	23.07%
2011	595.834	830.079	39.31%	182.702	228.556	25.10%
2012	638.464	854.349	33.81%	192.157	236.24	22.94%
2013	655.317	900.425	37.40%	197.544	247.62	25.35%
2014	699.605	944.933	35.07%	207.683	258.847	24.64%
2015	729.673	994.596	36.31%	215.53	271.128	25.80%

To assess the impact of the windfall on household welfare equivalent, variations were computed using equation (41) in Table 9. The results of the welfare impact of the natural resource windfall (in Table 14) show that on average over the twelve years, all the household groups benefit from a natural resource windfall. However the welfare of skilled households improves relatively more compared to the welfare of other household groups because of the relative increase in skilled household income.

Table 14: Welfare Impact of Windfall: 12 Years Average of Equivalent Variation

	Agricultural Household	Skilled Household	Unskilled Household	Informal Household	Capitalist Household
Baseline	24.10	88.05	18.52	26.26	6.30
Simulation I	45.01	217.76	33.49	48.47	10.93

CONCLUSION:

The results of Simulation I show that the impact of a natural resource windfall on Niger's economy is mixed. First, the windfall improves the economy's performance. Real GDP increases and household welfare improves. However, signs of Dutch disease show up as the CPI increases. Moreover, income inequality increases in Simulation I compared to the baseline scenario.

CHAPTER VI

USING A NATURAL RESOURCE WINDFALL FOR PUBLIC INVESTMENT

INTRODUCTION

In developing countries, public investment plays an important role in the development process. In fact, according to the World Bank (1994), public investment represents the “wheels,” if not the engine, of economic activity. Economic theory suggests that the government should provide or invest in sectors with positive externality (public goods) like infrastructure or education because private investments in these sectors tend to be very low. For example, there is little incentive for a private investor to invest in rural roads.

Many researchers, Glomm and Ravikumar (1992, 2003) and Agenor (2005) among others, have studied the growth effect of public expenditure on infrastructure, education, and health. They all come to the same conclusion: public investment, in particular in education and infrastructure, have a positive impact on economic growth by increasing the productivity of factors of production. For example, using an endogenous growth model, Agenor (2005) shows that an increase in public spending on infrastructure leads to an increase in the productivity of private capital, which increases growth. Schultz (1961) noted that increases in national output (USA) have been largely associated with land, man-hours, and physically reproducible capital. Schultz attributed this increase to investment in human capital. More recently, Jorgenson and Fraumeni (1992) analyzed the role of investment in education in US economic growth. They found that education investment accounted for a large part of the growth of the U.S economy during the post war era. In the context of developing countries, a study by Willis (1986) has shown the importance of education and productivity.

This chapter analyzes the impact of using uranium revenue for public investment purposes. The idea is to determine a better use of natural resource revenue in Niger. Three specific uses of windfall revenues are proposed. First, the entire windfall is used for education investment (Simulation II) and second, it used for infrastructure investment (Simulation III). Finally, to capture the synergy between education and infrastructure investment, a fourth simulation is conducted (Simulation IV) with the windfall invested in both education and infrastructure. These investment strategies are the core of Niger's poverty reduction strategies (see Niger Poverty Reduction Strategy Papers 2007). The three simulations are compared to Simulation I in the chapter above. Hence, Simulation I is the reference against which the performance of Simulations II, III, and IV are measured.

The chapter is divided as follows. The first part presents the modifications to the previous model to run the simulations. In the second part, the macroeconomic impact of each simulation is presented and analyzed. The third part presents the distributional effect of each simulation as well as the welfare impact. Finally, policy trade-offs are quantified with respect to growth and poverty.

THE MODEL MODIFICATIONS

To capture the effect of public investment in education and infrastructure, the initial model has been modified to include new equations. These equations serve as a transmission channel through which each investment policy affects the economy.

Education

Following the work by Becker (1964), Schultz (1961), and Nelson and Phelps (1966), many authors have studied the importance of human capital or education, in particular, in the productivity of labor and economic growth. These authors, Romer (1986), Lucas (1988), and Mankiw et al. (1992) to name a few, have all stressed the central role of human capital in the growth of nations. However, their models failed to capture the general equilibrium effects of human capital accumulation on investment. To my knowledge, only two authors used a CGE model to analyze the effect of investment in human capital on economic growth. Gibson (2005) used a structuralist CGE model to analyze the impact of human capital accumulation on poverty in an open economy. He found that the lack of private or public investment in human capital may hinder the export of skill-intensive goods. In a similar fashion, Jung and Thorbecke (2003) also used a CGE model to study education investment in Zambia and Tanzania. Their results confirm the positive role that education plays in the wellbeing of the two nations. The major drawback of the models is that they are both static. Moreover, the models are not detailed enough to capture the income inequality that may arise from investment in education.

The labor force in Niger (LF) grows at the same rate as the population (n) as given in equation (53) in Table 15. The sectoral supply of skilled labor ($LS_{i,t+1}$) in equation (54) evolves over time based on incoming educated labor[13] ($educ$) times the sectoral share of skilled labor ($ShareED_i$). Investment in education increases the supply of educated labor relative to the supply of unskilled labor by increasing the number of new incoming students with at least 10 years of schooling (equation 55). Moreover, investment in education is assumed to increase the productivity of skilled workers. Equation (56) shows the efficiency factor (Eff), which is influenced by government investment in human capital ($GHCINV$). The efficiency factor is set to 0.447, which is the proportion of students coming into the labor force in 2004 with at least 10 years of schooling. μ_{ed} is the elasticity of human capital with respect to national product and is set to 0.2 based on the estimate of Nachega and Fountaine (2006). The parameter λ_{HC} is calibrated such that the (Eff) is equal to 0.447 for the base run. The next period supply of unskilled labor in equation (57) is determined as being the difference between the labor force and skilled labor.

Table 15: Accumulation of Human Capital, Skilled and Unskilled.

(53) $LF_{i,t+1} = (1+n)LF_{it}$

(54) $LS_{i,t+1} = LS_{it} + Educ * ShareED_i$

(55) $Educ = eff .* Enr$

(56) $Eff = \lambda_{HC} * (GHCINV * GrowthHC)^{\mu_{ed}}$

(57) $LUS_{i,t+1} = LF_{i,t+1} - LS_{i,t+1}$

[13] "Educated labor force" is defined as people in the labor force with at least 10 years of schooling.

Infrastructure

The literature on CGE modeling of infrastructure investment is scant compared to the large body of literature on CGE modeling in general. However, Kim et al. (2004), Conrad and Heng (2002), Seung and Kraybill (2001), Adam and Bevan (2003), and Levy (2007), all of whom used a CGE model to analyze the effects of infrastructure investment on the economy, found that infrastructure investment has a positive impact on economic growth. With the exception of Seung and Kraybill (2001), who used a dynamic CGE of Ohio, all the models were static. This study follows closely the model developed for Chad by Levy (2007). However the model in this study differs significantly from hers in two ways. First, the model is dynamic, which allows it to capture the dynamic effects of infrastructure investment. Second, infrastructure investment is not only limited to roads but also includes energy (electricity) and irrigation schemes.

As in Levy (2007), investment in infrastructure is assumed to raise the productivity of both labor and capital. Equation (3') shows the modified version of the value-added function. The new function now incorporates a new term called total factor productivity ($TFPR$). The $TFPR$ can be interpreted as a shift parameter that raises the productivity of both capital and labor. Equation (58) in Table 16 shows that $TFPR$ is a function of government infrastructure investment ($GIFINV$) and growth in infrastructure investment ($GrowthIF$). The parameter (μ) is the elasticity of public capital with respect to national product. Nachega and Fontain (2006) studied the determinants of total factor productivity in Niger from 1963 to 2000. They found that growth of public capital had a significant positive impact on the growth rate of real GDP. They estimate (μ) to be on average 0.4. However Dessus and Herrara (2000), using panel data from developing countries studies, found the value of (μ) to range from 0.2 to 0.7. In this study μ is set at 0.2 to account for the very low level of infrastructure investment in Niger.

Table 16: Total Factor Productivity

(3') $$VA_{it} = TFPR * A_{it} LUS_{it}^{\alpha_{1i}} LS_{it}^{\alpha_{2i}} K_{it}^{1-\alpha_{1i}-\alpha_{2i}}$$

(58) $$TFPR = \lambda_{TFPR} * (GIFINV * GrowthIF)^{\mu}$$

($GrowthIF$) represents the growth of public infrastructure investment. The parameter λ_{TFPR} is calibrated such that the ($TFPR$) is equal to 1 for the base run and Simulation I.

SIMULATION RESULTS

Simulation II: Investment in Education

The objective of this simulation is to see whether investing the entire natural resource windfall in education will improve the performance of Niger's economy relative to Simulation I. As a result of such investment, the number of skilled workers in the economy increases whereas the number of unskilled workers shrinks. Table (17) presents the macroeconomic impact of this policy. Compared to Simulation I, many macroeconomic variables experience a substantial increase in 2005 due to the increase in government investment in education. The percentage difference in real GDP increases substantially from 61.65% in 2005 to 13.53% by the year 2015. Figure 12 illustrates the peak observed in 2005. Although there is a decline in the percentage difference in real GDP after 2005, there is still a significant positive gap between Simulation I and Simulation II. There are two reasons why the economy is performing better in Simulation II compared to Simulation I. First, investment in education increases the productivity of skilled workers. As a result, real GDP shoots up in 2005 in Simulation II compared to

Simulation I. Second, investment in education increases the supply of skilled workers relative to unskilled workers.

In addition, the percentage in the consumer price index jumps to 10.85% following the increase in real GDP. Over time, the percentage change in CPI falls to a level lower than in Simulation I, hence the negative percentage change number after 2006 (Figure 13). This is an important finding because it shows that when natural resource windfalls are used for investment in education, inflation does not rise significantly.

Figures 14 and 15, respectively, show the dynamic path of nominal skilled and unskilled wages under Simulations I and II. The investment in education increases the supply of skilled labor in the economy and shrinks the supply of unskilled workers. Hence, nominal skilled wages increase significantly in Simulation II compared to Simulation I. The increase in nominal skilled wages is due to two effects. First, the quantity effect which, as mentioned above, increases the number of skilled workers relative to unskilled workers and second, the nominal wage effect, which increases wages for skilled workers because of the increase in productivity.

Table 17: Macroeconomic Impact of Education Investment (% from Simulation I)

	2005	2006	2007	2008	2009	2010
Real GDP	61.65%	30.26%	14.50%	15.98%	15.01%	14.82%
CPI	10.85%	1.92%	-6.23%	-4.84%	-5.85%	-7.67%
Nominal Unskilled Wages	42.07%	15.42%	-8.32%	-5.66%	-7.87%	-11.23%
Nominal Skilled Wages	458.86%	128.59%	-8.59%	4.59%	-0.33%	-6.04%
Capital Income	21.08%	8.14%	-3.15%	-1.67%	-3.60%	-5.97%
Government Income	86.81%	31.61%	-11.09%	-4.30%	-6.37%	-9.02%
Private Saving	315.48%	100.40%	-8.81%	2.56%	-1.81%	-6.97%
Public Saving	639.73%	115.79%	-26.19%	-9.54%	-13.24%	-16.45%
Total Saving	263.35%	85.34%	-11.01%	0.01%	-3.88%	-8.40%
Total Investment	264.1%	53.8%	-22.2%	6.3%	5.4%	0.4%
Export	97.55%	33.99%	-8.08%	1.55%	-0.19%	-3.35%
Import	92.66%	34.74%	-6.65%	0.54%	-1.77%	-5.12%
Total Sectoral Production	97.67%	34.46%	-8.40%	0.56%	-1.28%	-4.84%

Table 17 (continued)

	2011	2012	2013	2014	2015	Average
Real GDP	17.29%	18.16%	16.62%	14.64%	13.53%	21.13%
CPI	-5.90%	-4.47%	-5.24%	-6.01%	-5.69%	-3.56%
Nominal Unskilled Wages	-7.03%	-4.00%	-6.58%	-9.35%	-9.90%	-1.13%
Nominal Skilled Wages	10.62%	21.96%	14.88%	7.44%	7.59%	58.14%
Capital Income	-3.74%	-2.21%	-3.91%	-5.71%	-6.25%	-0.64%
Government Income	0.17%	6.20%	2.40%	-1.74%	-1.60%	8.46%
Private Saving	7.93%	18.08%	11.76%	5.04%	5.18%	40.80%
Public Saving	0.30%	10.62%	3.95%	-2.76%	-2.46%	63.61%
Total Saving	5.77%	15.26%	9.33%	3.03%	3.20%	32.91%
Total Investment	17.0%	23.4%	13.7%	8.3%	10.4%	34.62%
Export	5.72%	10.77%	6.17%	2.18%	2.54%	13.53%
Import	3.20%	8.32%	4.16%	0.05%	-0.07%	11.82%
Total Sectoral Production	3.84%	8.75%	4.07%	-0.10%	-0.11%	12.24%

The increase in nominal skilled wages has a positive impact on private saving, which increases on average by 40.8%. Most of the increase in private saving comes from skilled households because of their higher marginal propensity to save. Table 17 also shows that public saving increases in Simulation II because of an increase in tax revenue. Public saving increases on average by 63.61%. Total saving increases by 32.91% over the 12 years. As a result, total investment in the economy shows an overall improvement by 34.62% in Simulation II compared to Simulation I. The increase in investment helps to explain the overall improvement of real GDP, which increases on average by 21.13%.

Figure 12
The Impact of Education Investment: Real GDP

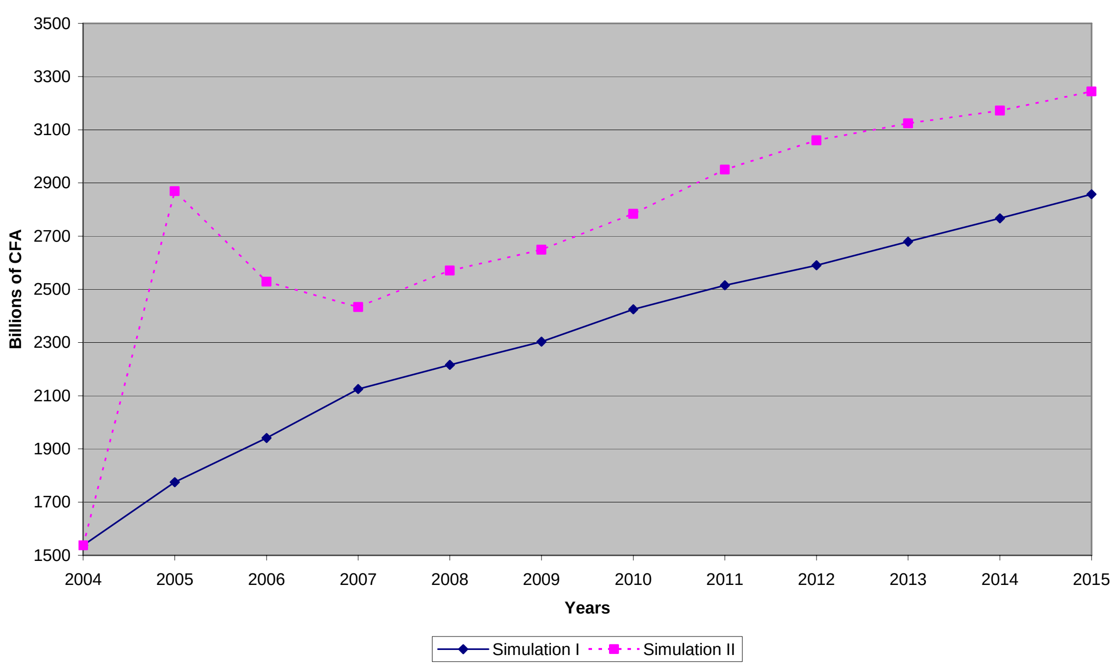


Figure 13
The Impact of Education Investment:CPI

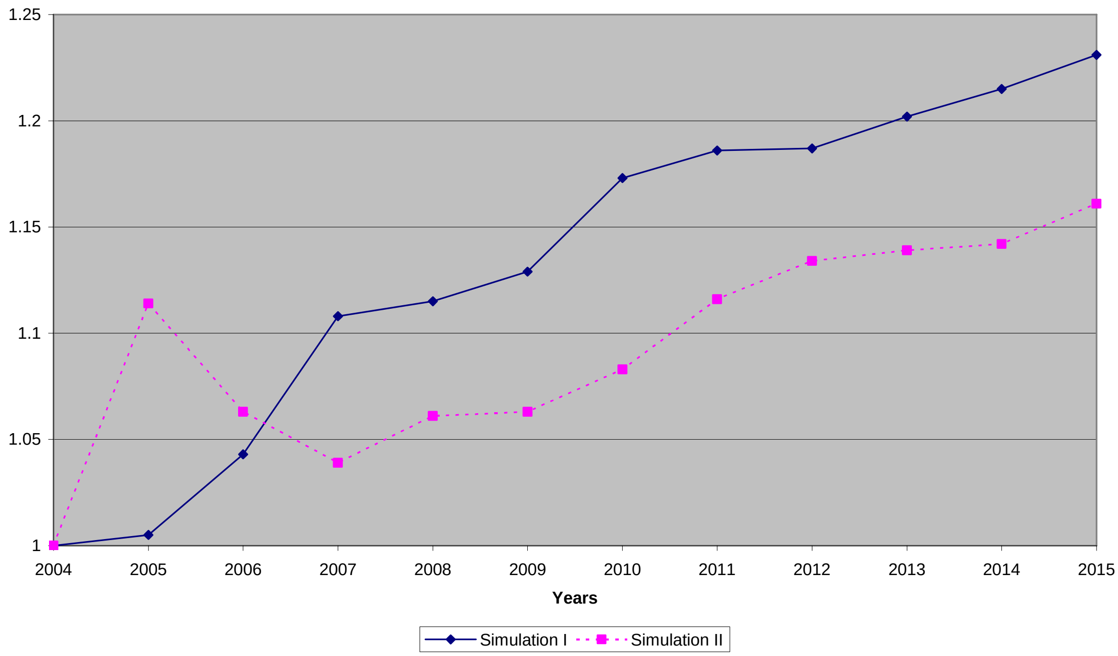


Figure 14
The Impact of Education Investment: Nominal Skilled Wage

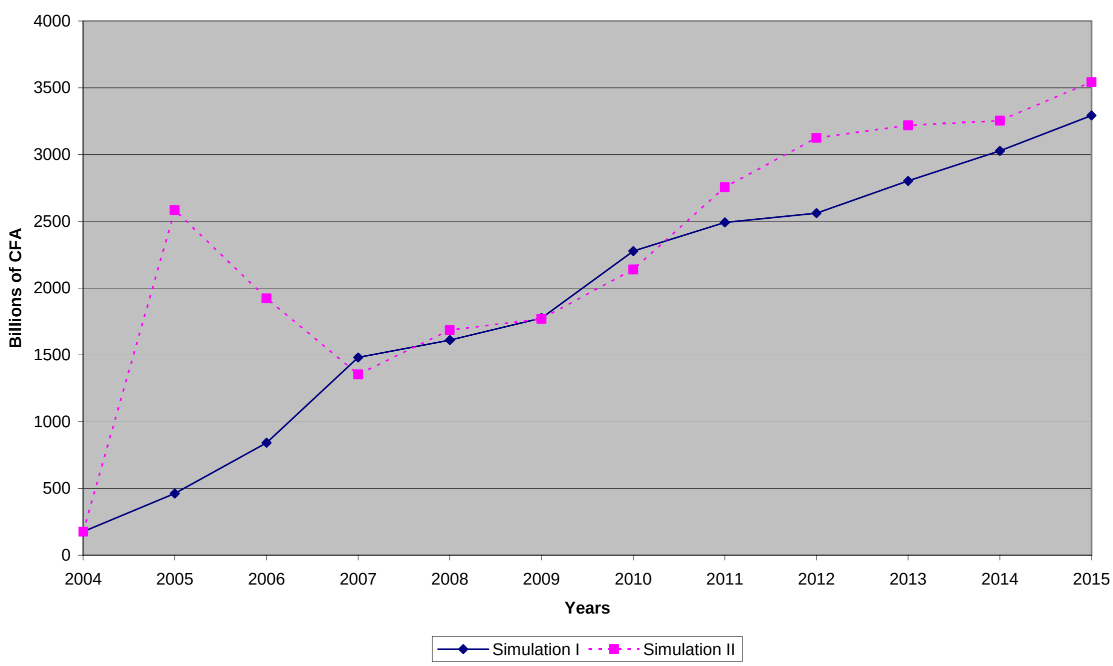
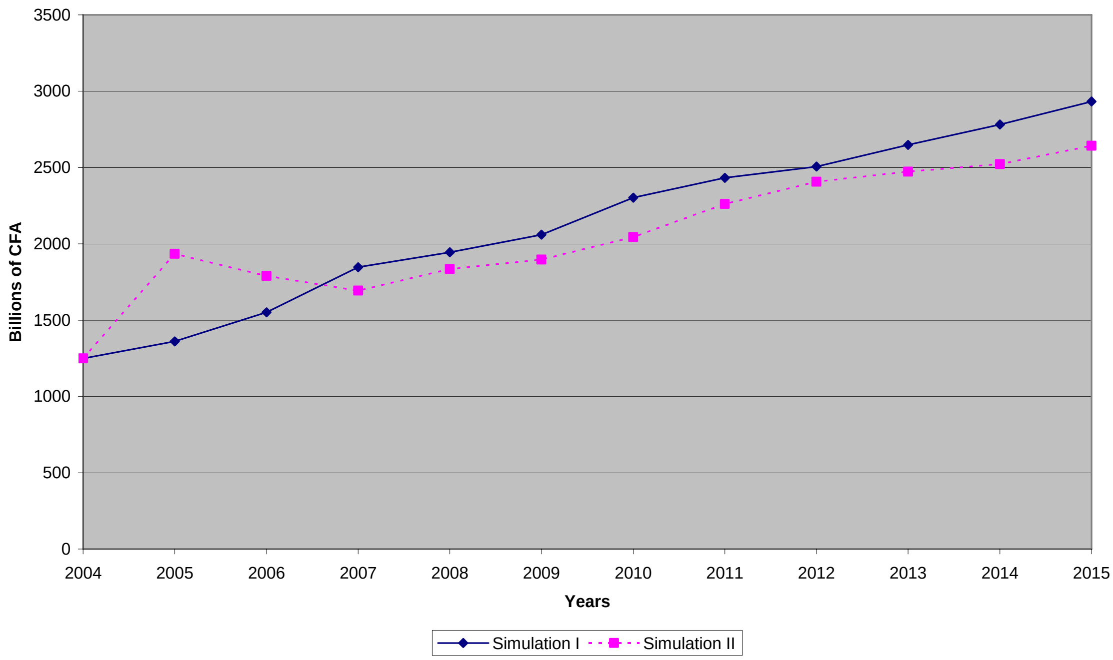


Figure 15
The Impact of Education Investment: Nominal Unskilled Wage



In addition, the increase in the nominal skilled wage has a positive effect on skilled household income, which sees an increase of 7.49% in 2015 relative to Simulation I (see Table 18). Moreover, total real consumption of skilled households increases on average over the 12 years as a result of the income increase. The other remaining household groups experience, on average over the 12 years, a decrease in income. For example, agricultural household income falls by 4.64% on average (see Table 18). Moreover, real consumption falls except for capitalist households, who experience a slight increase in consumption (1.38%). The fall in income and consumption of agricultural households, unskilled households, informal households, and capitalist households in Simulation II relative to Simulation I is explained by the "composition effect" (Knight and Sabot 1983). According to Knight and Sabot (1983), education investment changes the composition of the labor force by increasing the number of skilled households.

The consequence of differences in income among the representative households is growing income inequality. Figure 16 shows the Gini coefficient, which is greater in Simulation II compared to Simulation I. Empirical evidence has shown that investment in education tends to increase income inequality: for example, Glomm and Ravikumar (2003) showed that investment in public education may increase income inequality in the short run. The result can also be explained by the inverted U-shape hypothesis. According to the hypothesis, initial investment in education tends to increase income inequality but over time, inequality will decrease. The results obtained in this study are consistent with the hypothesis.

Table 18: Total Income by Household Group

	Agricultural Household			Skilled Household		
	Simulation I	Simulation II	% Change	Simulation I	Simulation II	% Change
2004	469.514	469.514	0.00%	163.255	163.255	0.00%
2005	541.218	713.528	31.84%	420.624	2319.236	451.38%
2006	608.202	661.959	8.84%	760.011	1727.325	127.28%
2007	712.714	626.903	-12.04%	1332.563	1217.596	-8.63%
2008	747.126	676.997	-9.39%	1449.751	1514.726	4.48%
2009	787.384	698.949	-11.23%	1597.97	1591.437	-0.41%
2010	873.167	750.899	-14.00%	2046.663	1921.904	-6.10%
2011	918.88	828.108	-9.88%	2239.344	2474.561	10.50%
2012	945.043	879.65	-6.92%	2302.373	2804.308	21.80%
2013	994.689	903.237	-9.19%	2518.109	2889.473	14.75%
2014	1042.04	920.203	-11.69%	2720.468	2920.057	7.34%
2015	1095.074	962.923	-12.07%	2958.062	3179.692	7.49%
Average	**811.2543**	**757.7392**	**-4.64%**	**1709.099**	**2060.298**	**52.49%**

Table 18 (continued)

	Unskilled Household			Informal Household		
	Simulation I	Simulation II	% Change	Simulation I	Simulation II	% Change
2004	319.229	319.229	0.00%	434.379	434.379	0.00%
2005	350.162	492.301	40.59%	481.803	677.236	40.56%
2006	398.259	456.033	14.51%	547.993	625.651	14.17%
2007	473.191	431.569	-8.80%	651.343	590.362	-9.36%
2008	498.003	467.403	-6.14%	685.229	639.931	-6.61%
2009	527.003	483.219	-8.31%	724.891	661.549	-8.74%
2010	588.543	520.335	-11.59%	809.676	712.999	-11.94%
2011	621.428	575.37	-7.41%	854.764	789.587	-7.63%
2012	640.34	612.19	-4.40%	880.473	840.638	-4.52%
2013	676.039	629.172	-6.93%	929.451	863.869	-7.06%
2014	710.097	641.449	-9.67%	976.16	880.517	-9.80%
2015	748.219	671.992	-10.19%	1028.496	922.801	-10.28%
Average	**545.8761**	**525.0218**	**-1.53%**	**750.3882**	**719.9599**	**-1.77%**

Table 18 (continued)

	Capitalist Household		
	Simulation I	Simulation II	% Change
2004	144.134	144.134	0.00%
2005	164.056	226.507	38.07%
2006	184.012	207.979	13.02%
2007	215.999	196.267	-9.14%
2008	226.719	212.873	-6.11%
2009	239.372	219.959	-8.11%
2010	265.862	237.186	-10.79%
2011	280.09	262.876	-6.15%
2012	288.418	280.005	-2.92%
2013	303.912	287.839	-5.29%
2014	318.682	293.485	-7.91%
2015	335.201	307.763	-8.19%
Average	**247.2048**	**239.7394**	**-1.12%**

Table 19: Total Real Consumption by Household Group

	Agricultural Household			Skilled Household		
	Simulation I	Simulation II	% Change	Simulation I	Simulation II	% Change
2004	451.257	451.257	0.00%	94.272	94.272	0.00%
2005	521.981	656.893	25.85%	238.802	1318.163	451.99%
2006	575.425	626.961	8.96%	423.87	977.903	130.71%
2007	656.681	595.042	-9.39%	735.406	683.399	-7.07%
2008	688.111	634.615	-7.77%	800.093	842.654	5.32%
2009	721.505	655.297	-9.18%	879.172	884.941	0.66%
2010	790.127	698.325	-11.62%	1122.22	1064.072	-5.18%
2011	830.11	761.95	-8.21%	1227.686	1364.315	11.13%
2012	854.331	805.396	-5.73%	1261.385	1542.528	22.29%
2013	896.54	825.505	-7.92%	1377.807	1585.429	15.07%
2014	937.662	839.398	-10.48%	1487.611	1596.948	7.35%
2015	983.234	872.63	-11.25%	1616.248	1729.396	7.00%
Average	**742.247**	**701.9391**	**-3.90%**	**938.7143**	**1140.335**	**53.27%**

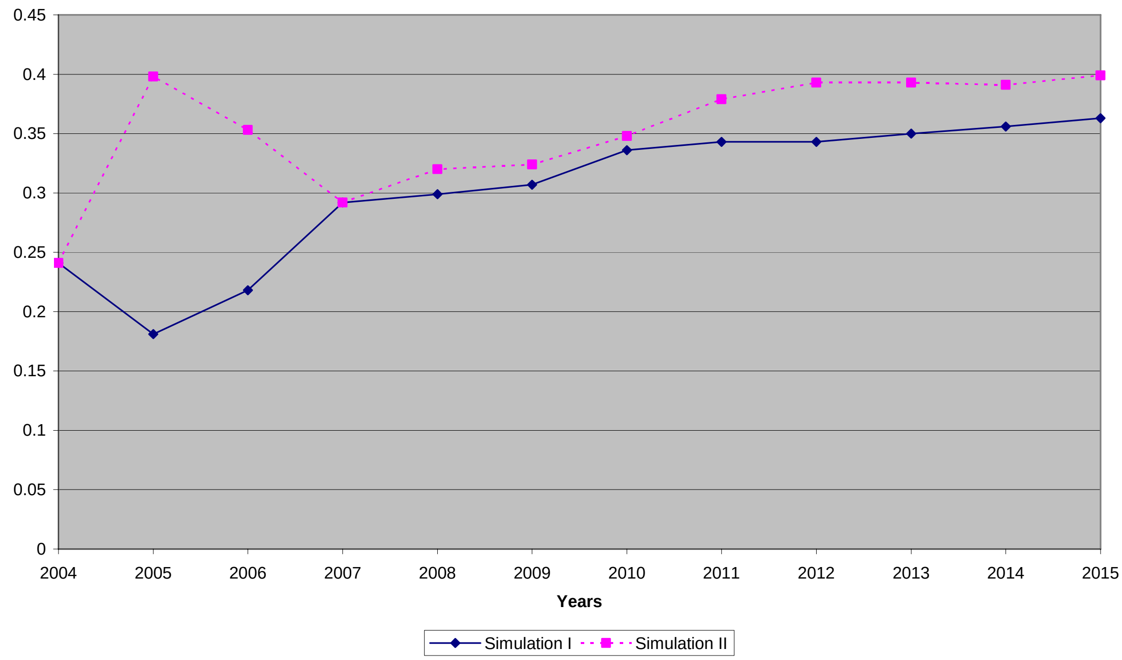
Table 19 (continued)

	Unskilled Household			Informal Household		
	Simulation I	Simulation II	% Change	Simulation I	Simulation II	% Change
2004	277.671	277.671	0.00%	419.095	419.095	0.00%
2005	308.983	426.024	37.88%	475.017	665.191	40.04%
2006	347.89	401.677	15.46%	539.206	623.8	15.69%
2007	407.361	377.576	-7.31%	637.11	581.201	-8.78%
2008	428.778	405.112	-5.52%	670.686	625.389	-6.75%
2009	451.887	418.877	-7.30%	706.979	646.782	-8.51%
2010	500.96	448.722	-10.43%	786.521	694.944	-11.64%
2011	528.509	493.143	-6.69%	830.079	767.294	-7.56%
2012	544.478	523.128	-3.92%	854.349	815.67	-4.53%
2013	573.615	536.627	-6.45%	900.425	836.807	-7.07%
2014	601.836	545.864	-9.30%	944.933	851.101	-9.93%
2015	633.22	569.013	-10.14%	994.596	888.842	-10.63%
Average	**467.099**	**451.9528**	**-1.14%**	**729.9163**	**701.343**	**-1.64%**

Table 19 (continued)

	Capitalist Household		
	Simulation I	Simulation II	% Change
2004	140.592	140.592	0.00%
2005	156.048	192.978	23.67%
2006	166.82	185.422	11.15%
2007	183.858	179.733	-2.24%
2008	192.501	190.905	-0.83%
2009	201.711	197.171	-2.25%
2010	217.822	209.233	-3.94%
2011	228.556	226.636	-0.84%
2012	236.24	238.902	1.13%
2013	247.62	245.089	-1.02%
2014	258.847	249.467	-3.62%
2015	271.128	258.516	-4.65%
Average	**208.4786**	**209.5537**	**1.38%**

Figure: 16
The Impact of Education Investment: Gini Coffecient



Simulation III: Investment in Infrastructure

One of the major problems that Niger's economy faces is its poor infrastructure. Any long-term development planning should incorporate investment in infrastructure. This part of the study assumes that the natural resource windfall is invested in infrastructure, which is assumed to raise the productivity of both capital and labor. Table 19 provides the macroeconomic impact of this policy.

Table 20: Macroeconomic Impact of Infrastructure Investment (% from Simulation I)

	2005	2006	2007	2008	2009	2010
Real GDP	116.27%	48.32%	31.63%	32.23%	21.69%	19.46%
CPI	13.43%	3.16%	-4.60%	-3.14%	-10.45%	-13.04%
Nominal Unskilled Wage	114.61%	51.76%	21.72%	24.96%	3.93%	-2.91%
Nominal Skilled Wage	858.37%	124.73%	-13.39%	-0.54%	-58.94%	-63.70%
Capital Income	56.89%	41.47%	30.22%	31.66%	18.84%	14.01%
Government Income	204.50%	51.97%	4.67%	11.22%	-17.98%	-24.93%
Private Saving	602.31%	105.84%	-7.66%	3.38%	-48.79%	-54.94%
Public Saving	1507.05%	190.39%	11.02%	24.90%	-37.36%	-45.46%
Total Saving	529.04%	99.94%	-3.40%	7.10%	-41.98%	-48.83%
Total Investment	724.5%	37.0%	-20.9%	14.6%	-34.0%	-38.5%
Export	268.14%	49.24%	5.52%	16.28%	-12.33%	-18.72%
Import	225.81%	56.71%	11.26%	18.88%	-9.97%	-17.17%
Total Sectoral Production	283.95%	54.15%	7.66%	18.48%	-10.19%	-17.50%

Table 20 (continued)

	2011	2012	2013	2014	2015	Average
Real GDP	23.59%	26.60%	28.28%	28.40%	28.37%	36.80%
CPI	-10.96%	-8.68%	-7.49%	-7.65%	-7.96%	-5.22%
Nominal Unskilled Wage	2.82%	9.14%	12.49%	12.18%	11.42%	23.83%
Nominal Skilled Wage	-44.89%	-28.20%	-17.41%	-16.44%	-16.47%	65.74%
Capital Income	16.73%	19.97%	21.54%	21.14%	20.50%	26.63%
Government Income	-15.52%	-6.17%	-0.77%	-0.79%	-1.34%	18.62%
Private Saving	-38.28%	-23.09%	-13.50%	-12.79%	-13.00%	45.41%
Public Saving	-27.06%	-10.57%	-1.27%	-1.26%	-2.06%	146.21%
Total Saving	-33.26%	-18.86%	-10.00%	-9.50%	-9.86%	41.85%
Total Investment	-17.4%	-2.4%	3.6%	1.4%	0.7%	60.80%
Export	-8.42%	0.87%	5.55%	4.98%	4.29%	28.67%
Import	-7.88%	1.12%	5.94%	5.60%	4.88%	26.84%
Total Sectoral Production	-7.58%	1.77%	6.46%	5.87%	5.14%	31.66%

Following the investment in infrastructure, real GDP increases by 116.27% in 2005 (see Table 20). This increase in GDP can be attributed to the massive investments that take place in 2005. Over time, as Figure 17 shows, real GDP declines but still remains at higher levels than in Simulation I. On average, real GDP is up by 36.80% in Simulation III relative to Simulation I. Moreover, this increase in economic activity does not raise the consumer price index. In fact CPI falls on average over the 12 years by 5.22%. Figure 18 shows the dynamic path of CPI, which increases in 2005 by 13.43% primarily as a result of the massive investment taking place in the country.

Capital income increases sharply, reflecting the rising productivity of capital due to new infrastructure. In addition, nominal unskilled wages increase considerably (see Figure 20), albeit it declines overtime. This decline implies an even larger increase in the real wages of unskilled workers. On average wages increase by 23.83% in comparison to Simulation I. The nominal skilled wage also increases considerably during the first two years, before falling following the investment in infrastructure. However, on average over 12 years, nominal skilled wages are up 65.74% compared to Simulation I (see Figure 23).

Figure 17
The Impact of Infrastructure Investment: Real GDP

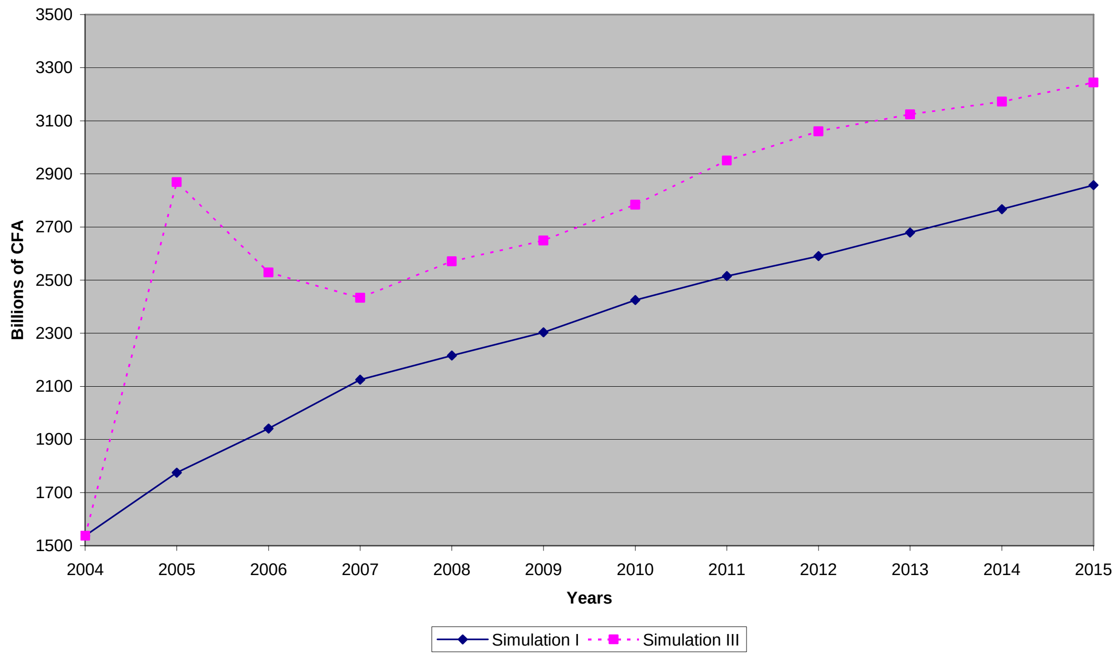


Figure 18
The Impact of Infrastructure Investment: CPI

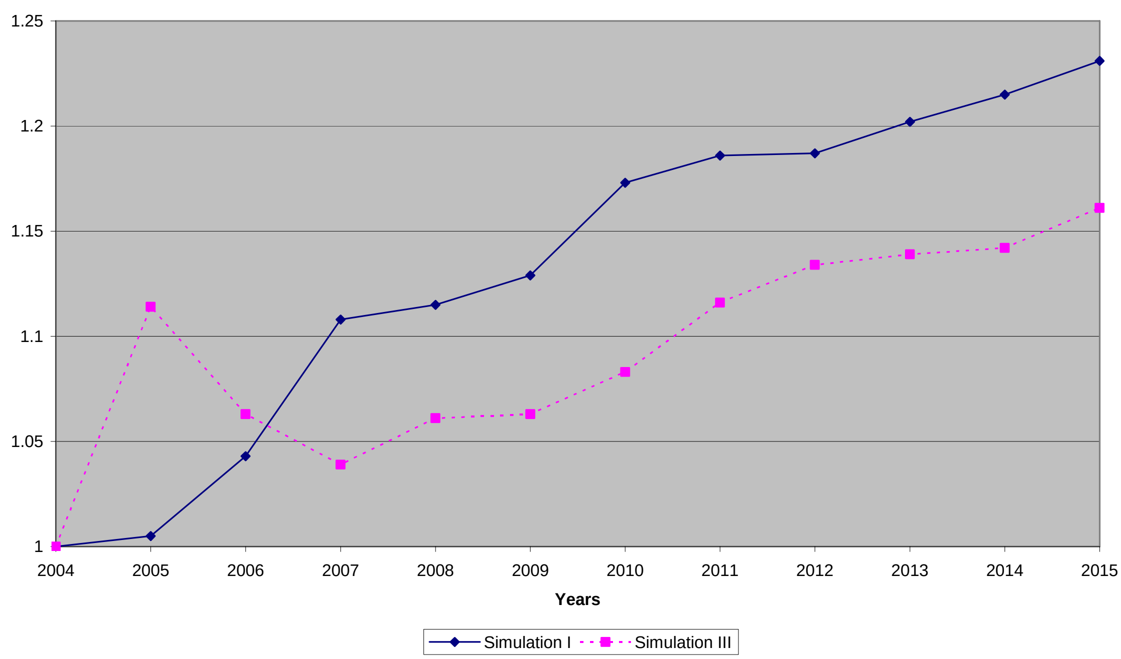


Figure 19
The Impact of Infrastructure Investment: Nominal Skilled Wage

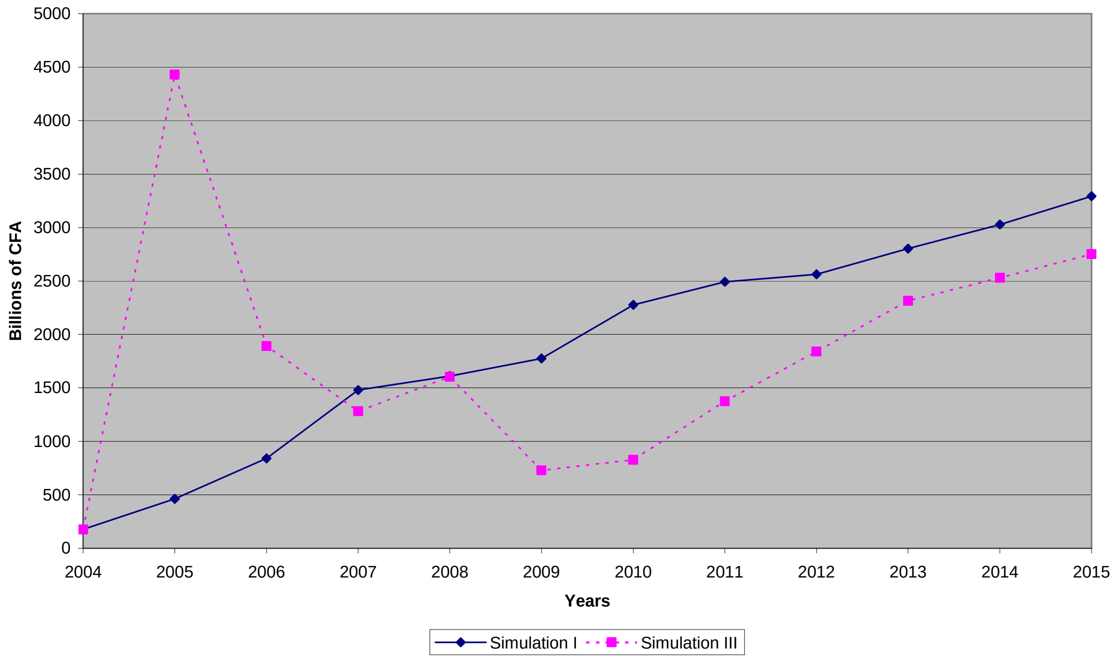
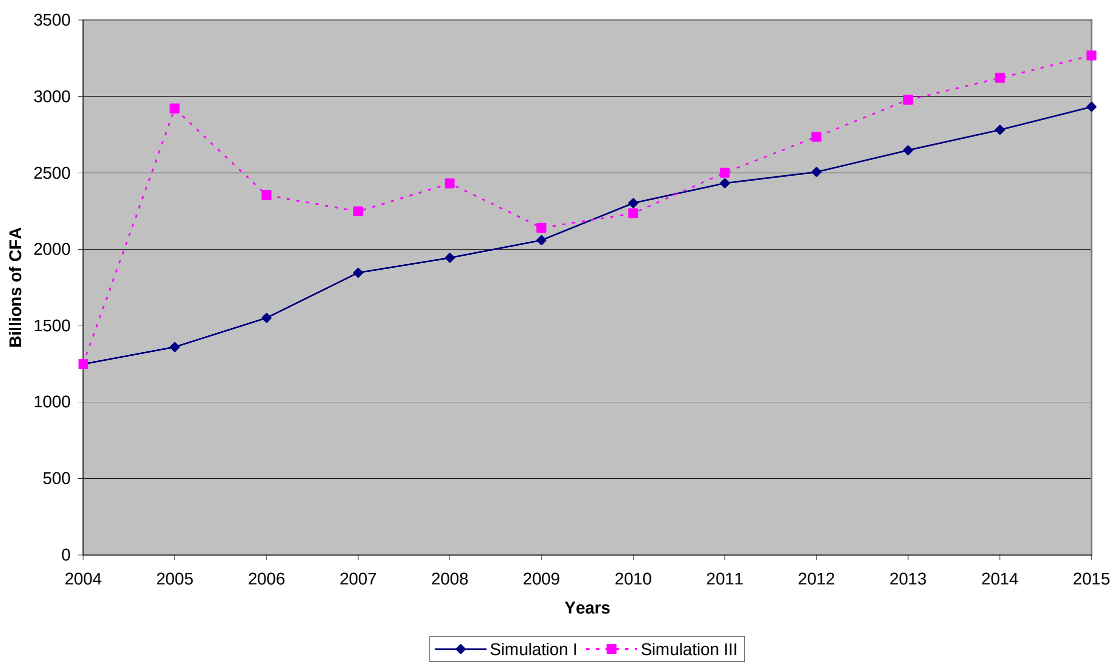


Figure 20
The Impact of Infrastructure Investment: Nominal Unskilled Wage



Private and public saving increases sharply the first two years subsequent to the investment in infrastructure (see Table 19) before falling to a lower level than in Simulation I, albeit on average over the 12 years, private and public saving increases to 45.41% and 146% respectively over the level for Simulation I. As a result of an increase in private and public saving, total saving increases on average 41.85% over the level for Simulation I. Total investment, which is linked to total saving, also increases by 60.80% over the level for Simulation I.

Household income also increases dramatically as a result of infrastructure investment. Skilled households experience on average a higher level of income in Simulation III, around 59.2% (see Table 21) compared to Simulation I. The other household groups experience a steady increase in their income in Simulation III relative to Simulation I. The increase in household income is the result of the increase in labor income mentioned earlier. Real consumption by household groups as seen in Table 21 shows a pattern similar to that in Table 22 because real household consumption increases as a result of increases in household income.

Figure 21 shows the path of the Gini coefficient index. After increasing sharply in 2005, the index of inequality falls considerably and remains low compared to Simulation I. The initial increase in the Gini coefficient can be explained by the sharp increase observed in skilled labor income, which increases skilled household income.

Table 21: Total Income by Household Group

	Agricultural Household			Skilled Household		
	Simulation I	Simulation III	% Change	Simulation I	Simulation III	% Change
2004	469.514	469.514	0.00%	163.255	163.255	0.00%
2005	541.218	1060.972	96.03%	420.624	3974.778	844.97%
2006	608.202	857.77	41.03%	760.011	1700.665	123.77%
2007	712.714	819.77	15.02%	1332.563	1156.44	-13.22%
2008	747.126	883.964	18.32%	1449.751	1443.449	-0.43%
2009	787.384	780.998	-0.81%	1597.97	661.883	-58.58%
2010	873.167	814.329	-6.74%	2046.663	749.19	-63.39%
2011	918.88	908.005	-1.18%	2239.344	1239.134	-44.67%
2012	945.043	991	4.86%	2302.373	1656.954	-28.03%
2013	994.689	1076.497	8.22%	2518.109	2082.707	-17.29%
2014	1042.04	1126.68	8.12%	2720.468	2276.084	-16.33%
2015	1095.074	1178.219	7.59%	2958.062	2474.031	-16.36%
Average	**811.2543**	**913.9765**	**15.87%**	**1709.099**	**1631.548**	**59.20%**

Table 21 (continued)

	Unskilled Household			Informal Household		
	Simulation I	Simulation III	% Change	Simulation I	Simulation III	% Change
2004	319.229	319.229	0.00%	434.379	434.379	0.00%
2005	350.162	742.136	111.94%	481.803	1020.403	111.79%
2006	398.259	598.798	50.35%	547.993	817.148	49.12%
2007	473.191	572.17	20.92%	651.343	778.879	19.58%
2008	498.003	618.319	24.16%	685.229	842.227	22.91%
2009	527.003	544.93	3.40%	724.891	739.971	2.08%
2010	588.543	569.01	-3.32%	809.676	772.738	-4.56%
2011	621.428	636.216	2.38%	854.764	865.325	1.24%
2012	640.34	695.791	8.66%	880.473	947.322	7.59%
2013	676.039	757.169	12.00%	929.451	1031.782	11.01%
2014	710.097	793.304	11.72%	976.16	1081.241	10.76%
2015	748.219	830.416	10.99%	1028.496	1132.036	10.07%
Average	**545.8761**	**639.7907**	**21.10%**	**750.3882**	**871.9543**	**20.13%**

Table 21 (continued)

	Capitalist Household		
	Simulation I	Simulation III	% Change
2004	144.134	144.134	0.00%
2005	164.056	324.991	98.10%
2006	184.012	262.7	42.76%
2007	215.999	253.31	17.27%
2008	226.719	273.183	20.49%
2009	239.372	241.863	1.04%
2010	265.862	252.422	-5.06%
2011	280.09	281.233	0.41%
2012	288.418	306.795	6.37%
2013	303.912	333.217	9.64%
2014	318.682	348.905	9.48%
2015	335.201	365.053	8.91%
Average	**247.2048**	**282.3172**	**17.45%**

Table 22: Total Consumption by Household Group

	Agricultural Household			Skilled Household		
	Simulation I	Simulation III	% Change	Simulation I	Simulation III	% Change
2004	451.257	451.257	0.00%	94.272	94.272	0.00%
2005	521.981	1159.184	122.07%	238.802	2707.958	1033.98%
2006	575.425	827.45	43.80%	423.87	974.059	129.80%
2007	656.681	775.007	18.02%	735.406	644.372	-12.38%
2008	688.111	828.361	20.38%	800.093	799.711	-0.05%
2009	721.505	752.747	4.33%	879.172	374.265	-57.43%
2010	790.127	780.347	-1.24%	1122.22	421.156	-62.47%
2011	830.11	858.095	3.37%	1227.686	688.443	-43.92%
2012	854.331	929.224	8.77%	1261.385	917.018	-27.30%
2013	896.54	1002.584	11.83%	1377.807	1149.586	-16.56%
2014	937.662	1047.571	11.72%	1487.611	1255.382	-15.61%
2015	983.234	1093.264	11.19%	1616.248	1363.005	-15.67%
Average	**742.247**	**875.4243**	**21.19%**	**938.7143**	**949.1023**	**76.03%**

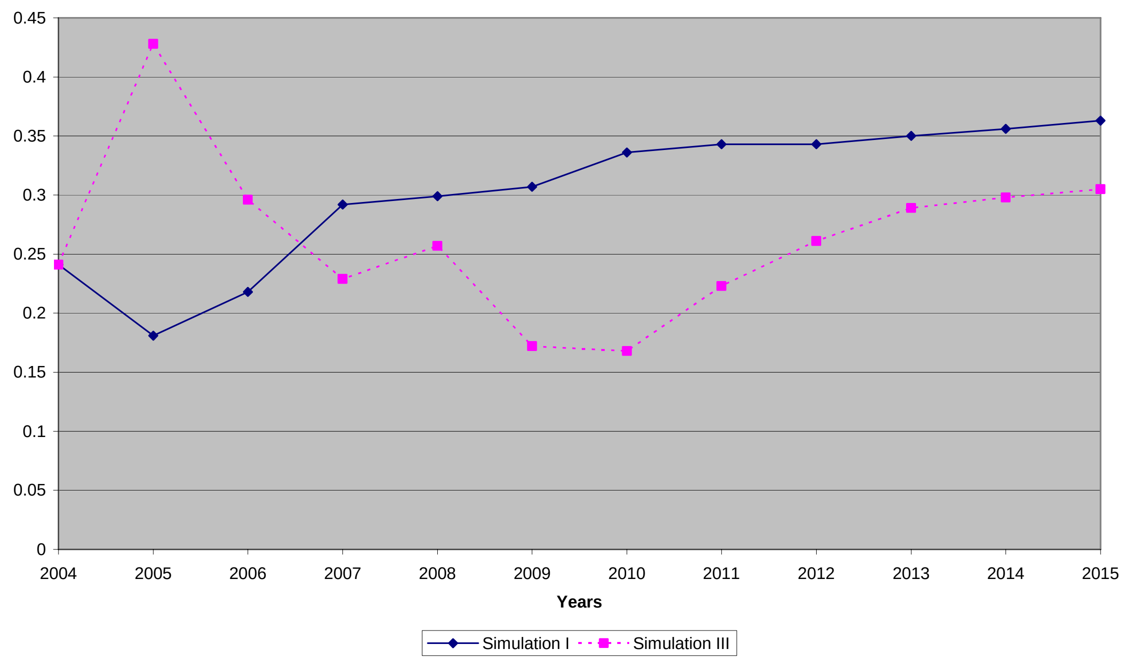
Table 22 (continued)

	Unskilled Household			Informal Household		
	Simulation I	Simulation III	% Change	Simulation I	Simulation III	% Change
2004	277.671	277.671	0.00%	419.095	419.095	0.00%
2005	308.983	779.883	152.40%	475.017	1248.15	162.76%
2006	347.89	537.93	54.63%	539.206	832.276	54.35%
2007	407.361	499.141	22.53%	637.11	764.742	20.03%
2008	428.778	536.226	25.06%	670.686	823.594	22.80%
2009	451.887	479.91	6.20%	706.979	729.112	3.13%
2010	500.96	498.763	-0.44%	786.521	758.346	-3.58%
2011	528.509	553.52	4.73%	830.079	846.414	1.97%
2012	544.478	603.032	10.75%	854.349	925.515	8.33%
2013	573.615	653.878	13.99%	900.425	1006.535	11.78%
2014	601.836	684.412	13.72%	944.933	1054.313	11.58%
2015	633.22	715.397	12.98%	994.596	1102.753	10.87%
Average	**467.099**	**568.3136**	**26.38%**	**729.9163**	**875.9038**	**25.34%**

Table 22 (continued)

	Capitalist Household		
	Simulation I	Simulation III	% Change
2004	140.592	140.592	0.00%
2005	156.048	299.988	92.24%
2006	166.82	236.474	41.75%
2007	183.858	230.39	25.31%
2008	192.501	244.214	26.86%
2009	201.711	229.902	13.98%
2010	217.822	237.935	9.23%
2011	228.556	256.994	12.44%
2012	236.24	275.121	16.46%
2013	247.62	294.181	18.80%
2014	258.847	306.884	18.56%
2015	271.128	319.882	17.98%
Average	**208.4786**	**256.0464**	**24.47%**

Figure 21
The Impact of Infrastructure Investment: GINI



Simulation IV: Mixed Investment Policy

The objective of this section is to investigate the synergy between education investment and infrastructure investment. The idea is that educated labor needs to have infrastructure to become fully productive. Also better infrastructure, although good for an economy, might not be as productive without an educated labor force. The following simulation tries to capture this inter-relationship between education and infrastructure. In Simulation IV, the government is assumed to spend half of the windfall on infrastructure and the other half on education.

Table 23 summarizes the macroeconomic impact of this policy. On average, real GDP is 58.98% higher in Simulation IV compared to Simulation I.

Table 23: Macroeconomic Impact of Mix Investment (% from Simulation I)

	2005	2006	2007	2008	2009	2010
Real GDP	170.65%	63.47%	49.42%	47.93%	49.83%	46.46%
CPI	26.47%	-0.67%	-1.53%	-1.61%	-0.44%	-3.92%
Nominal Unskilled Wages	171.41%	44.14%	32.29%	31.07%	35.21%	25.08%
Nominal Skilled Wages	1595.11%	152.57%	53.78%	52.58%	71.32%	39.78%
Capital Income	85.51%	34.90%	35.50%	34.07%	35.42%	29.07%
Government Income	351.59%	49.62%	26.20%	27.74%	37.94%	24.35%
Private Saving	1106.87%	125.19%	49.42%	48.38%	64.84%	37.29%
Public Saving	2591.07%	181.77%	61.85%	61.55%	78.82%	44.40%
Total Saving	955.82%	111.87%	46.24%	45.92%	61.51%	35.94%
Total Investment	1233.8%	23.5%	5.5%	44.4%	69.4%	39.6%
Export	445.89%	49.53%	27.75%	35.09%	46.29%	31.57%
Import	384.17%	58.18%	35.29%	38.05%	47.37%	32.69%
Total Sectoral Production	467.72%	54.43%	29.55%	37.24%	48.16%	32.58%

Table 23 (continued)

	2011	2012	2013	2014	2015	Average
Real GDP	45.45%	44.88%	45.05%	43.61%	42.03%	58.98%
CPI	-4.22%	-3.96%	-3.33%	-4.12%	-4.96%	-0.21%
Nominal Unskilled Wages	23.49%	23.67%	24.85%	21.98%	18.91%	41.10%
Nominal Skilled Wages	36.67%	38.48%	43.84%	37.01%	30.00%	195.56%
Capital Income	27.90%	27.66%	28.00%	26.00%	23.89%	35.26%
Government Income	23.35%	24.43%	27.93%	24.27%	20.43%	57.99%
Private Saving	34.49%	36.07%	40.94%	34.74%	28.34%	146.05%
Public Saving	40.70%	41.85%	45.92%	38.60%	31.46%	292.54%
Total Saving	33.40%	34.87%	39.48%	33.59%	27.52%	129.65%
Total Investment	41.2%	43.5%	46.9%	39.2%	34.2%	147.38%
Export	31.02%	32.09%	34.93%	30.75%	26.98%	71.99%
Import	31.36%	32.07%	34.67%	30.57%	26.52%	68.27%
Total Sectoral Production	31.52%	32.35%	34.88%	30.46%	26.40%	75.03%

Figure 22 shows the dynamic path of real GDP under Simulations I through IV. As expected, the mixed policy yields the highest level of GDP compared to the first three simulations. This result supports the hypothesis that there is a complementary effect between education and infrastructure. As a result, total saving increases considerably in the economy, thereby increasing the available funds for investment.

Figure 22
The Impact of Mix Investment: Real GDP

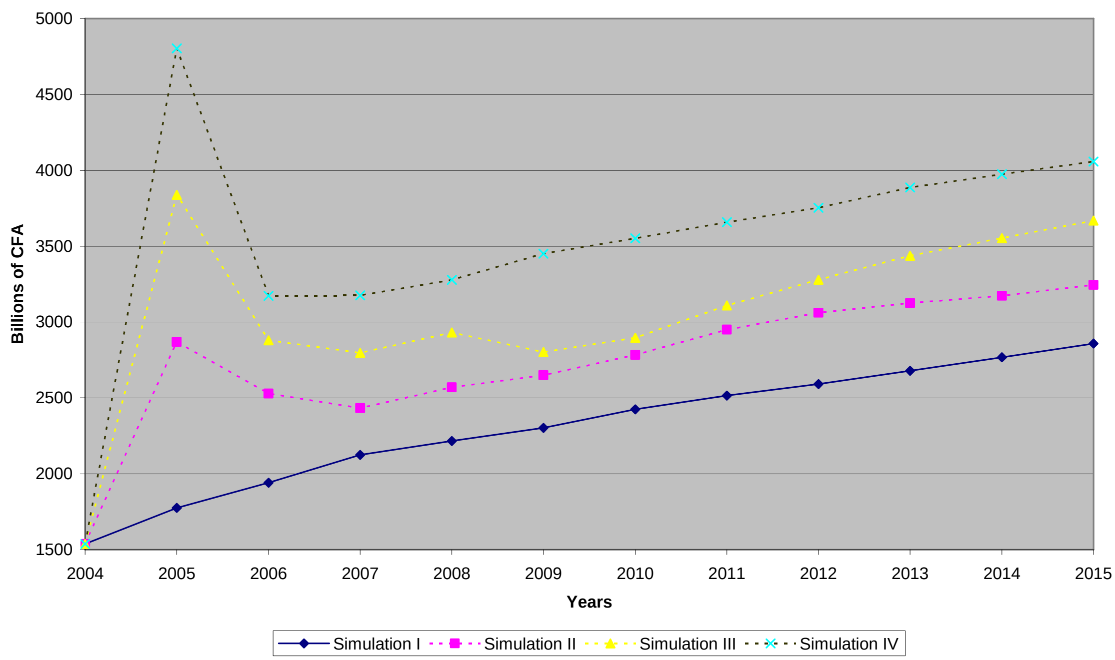
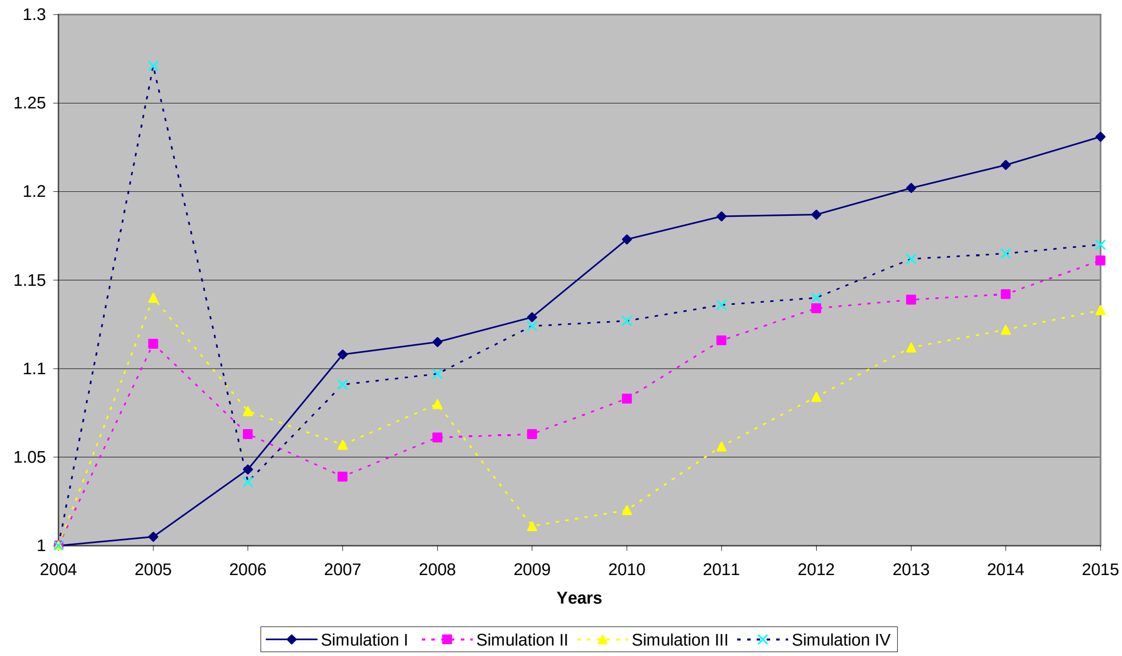


Figure 27 shows the dynamic path of the consumer price index. Although the CPI is higher in Simulation IV compared to Simulations II and III (Figure 23), it is still below the level observed in Simulation I. This result is interesting because it shows that simultaneous investment in education and infrastructure yields the highest level of GDP possible with relatively modest inflation and therefore lowers the risk of Dutch disease.

Figure 23
The Impact of Mix Investment: CPI



Simulation IV shows a positive impact on household income. Each household group experiences a net gain in terms of income and consumption (see Tables 24 and 25 and Figures 24 through 29). This gain is due to higher levels of nominal unskilled and skilled wages as well as capital, the major sources of income for households. However the Gini coefficient index as shown in Figure 33 is on average higher in Simulation IV than in the other simulations. This can be explained by the fact that half of the windfall is invested in education, which increases the Gini coefficient because of the composition effect, as mentioned earlier.

Table 24: Total Household Income

	Agricultural Household			Skilled Household		
	Simulation I	Simulation IV	% Change	Simulation I	Simulation IV	% Change
2004	469.514	469.514	0.00%	163.255	163.255	0.00%
2005	541.218	1338.797	147.37%	420.624	7023.683	1569.82%
2006	608.202	817.368	34.39%	760.011	1909.536	151.25%
2007	712.714	890.231	24.91%	1332.563	2046.089	53.55%
2008	747.126	927.539	24.15%	1449.751	2208.847	52.36%
2009	787.384	1010.917	28.39%	1597.97	2732.849	71.02%
2010	873.167	1044.498	19.62%	2046.663	2858.305	39.66%
2011	918.88	1088.133	18.42%	2239.344	3058	36.56%
2012	945.043	1122.153	18.74%	2302.373	3185.602	38.36%
2013	994.689	1194.888	20.13%	2518.109	3618.636	43.70%
2014	1042.04	1225.868	17.64%	2720.468	3724.44	36.90%
2015	1095.074	1258.763	14.95%	2958.062	3843.207	29.92%
Average	**811.254**	**1032.389**	**30.73%**	**1709.099**	**3031.037**	**176.93%**

Table 24 (continued)

	Unskilled Household			Informal Household		
	Simulation I	Simulation IV	% Change	Simulation I	Simulation IV	% Change
2004	319.229	319.229	0.00%	434.379	434.379	0.00%
2005	350.162	937.765	167.81%	481.803	1298.015	169.41%
2006	398.259	568.846	42.83%	547.993	778.012	41.97%
2007	473.191	621.524	31.35%	651.343	849.509	30.42%
2008	498.003	648.343	30.19%	685.229	886.314	29.35%
2009	527.003	707.95	34.34%	724.891	968.887	33.66%
2010	588.543	732.129	24.40%	809.676	1001.972	23.75%
2011	621.428	763.47	22.86%	854.764	1045.036	22.26%
2012	640.34	787.961	23.05%	880.473	1078.554	22.50%
2013	676.039	840.001	24.25%	929.451	1150.535	23.79%
2014	710.097	862.325	21.44%	976.16	1181.037	20.99%
2015	748.219	886.014	18.42%	1028.496	1213.438	17.98%
Average	**545.876**	**722.963**	**36.74%**	**750.388**	**990.474**	**36.34%**

Table 24 (continued)

	Capitalist Household		
	Simulation I	Simulation IV	% Change
2004	144.134	144.134	0.00%
2005	164.056	426.434	159.93%
2006	184.012	254.332	38.21%
2007	215.999	279.898	29.58%
2008	226.719	291.786	28.70%
2009	239.372	318.589	33.09%
2010	265.862	329.422	23.91%
2011	280.09	343.617	22.68%
2012	288.418	354.683	22.98%
2013	303.912	378.302	24.48%
2014	318.682	388.391	21.87%
2015	335.201	399.14	19.07%
Average	**247.204**	**325.727**	**35.38%**

Table 25: Total Consumption by Household Group

	Agricultural Household			Skilled Household		
	Simulation I	Simulation VI	% Change	Simulation I	Simulation VI	% Change
2004	451.257	451.257	0.00%	94.272	94.272	0.00%
2005	521.981	1415.238	171.13%	238.802	4723.829	1878.14%
2006	575.425	807.934	40.41%	423.87	1116.056	163.30%
2007	656.681	830.292	26.44%	735.406	1135.611	54.42%
2008	688.111	864.172	25.59%	800.093	1224.048	52.99%
2009	721.505	936.016	29.73%	879.172	1511.773	71.95%
2010	790.127	967.305	22.42%	1122.22	1580.479	40.84%
2011	830.11	1005.491	21.13%	1227.686	1687.609	37.46%
2012	854.331	1035.993	21.26%	1261.385	1755.64	39.18%
2013	896.54	1098.063	22.48%	1377.807	1989.647	44.41%
2014	937.662	1126.006	20.09%	1487.611	2045.29	37.49%
2015	983.234	1154.505	17.42%	1616.248	2106.141	30.31%
Average	**742.247**	**974.356**	**34.84%**	**938.714**	**1747.533**	**204.21%**

Table 25 (continued)

	Unskilled Household			Informal Household		
	Simulation I	Simulation VI	% Change	Simulation I	Simulation VI	% Change
2004	277.671	277.671	0.00%	419.095	419.095	0.00%
2005	308.983	956.605	209.60%	475.017	1540.547	224.31%
2006	347.89	521.214	49.82%	539.206	806.625	49.59%
2007	407.361	537.344	31.91%	637.11	829.128	30.14%
2008	428.778	560.032	30.61%	670.686	864.556	28.91%
2009	451.887	609.598	34.90%	706.979	944.2	33.55%
2010	500.96	630.415	25.84%	786.521	976.523	24.16%
2011	528.509	656.144	24.15%	830.079	1016.892	22.51%
2012	544.478	676.486	24.24%	854.349	1048.5	22.73%
2013	573.615	718.969	25.34%	900.425	1116.36	23.98%
2014	601.836	737.557	22.55%	944.933	1145.225	21.20%
2015	633.22	756.624	19.49%	994.596	1174.99	18.14%
Average	**467.099**	**636.555**	**41.54%**	**729.916**	**990.220**	**41.60%**

Table 25 (continued)

	Capitalist Household		
	Simulation I	Simulation VI	% Change
2004	140.592	140.592	0.00%
2005	156.048	383.676	145.87%
2006	166.82	237.461	42.35%
2007	183.858	248.313	35.06%
2008	192.501	258.208	34.13%
2009	201.711	277.834	37.74%
2010	217.822	287.385	31.94%
2011	228.556	298.804	30.74%
2012	236.24	308.182	30.45%
2013	247.62	325.764	31.56%
2014	258.847	334.368	29.18%
2015	271.128	343.051	26.53%
Average	**208.479**	**286.970**	**39.63%**

Figrue 24
The Impact of Mix Investment: Agricultural Household Total Consumption

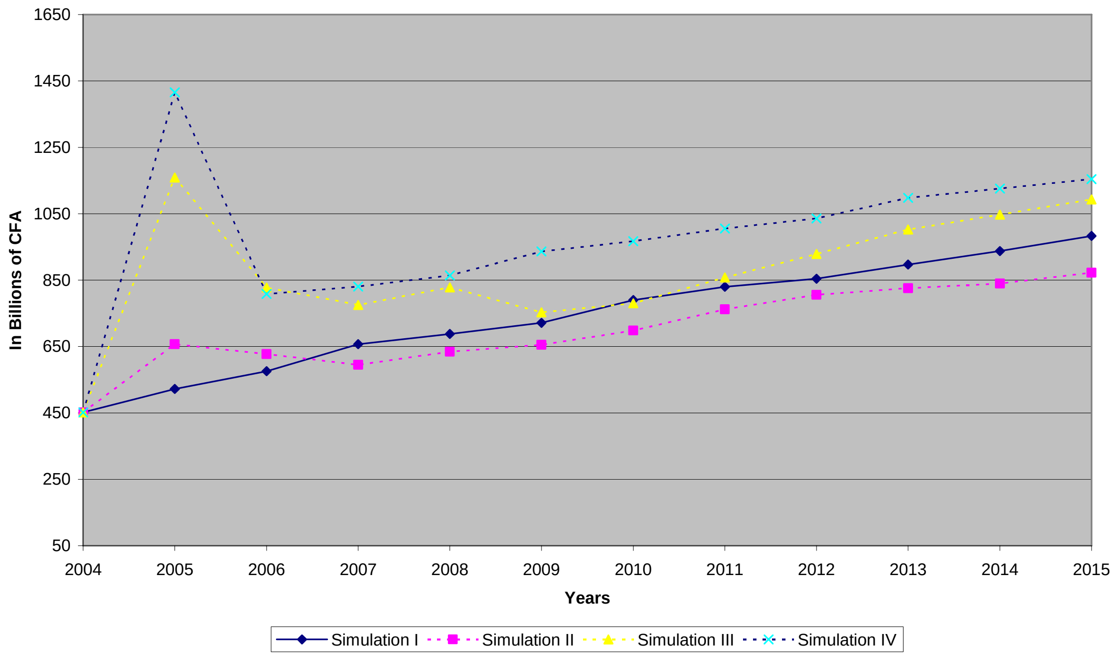


Figure 25
The Impact of Mix Investment: Skilled Household Total Consumption

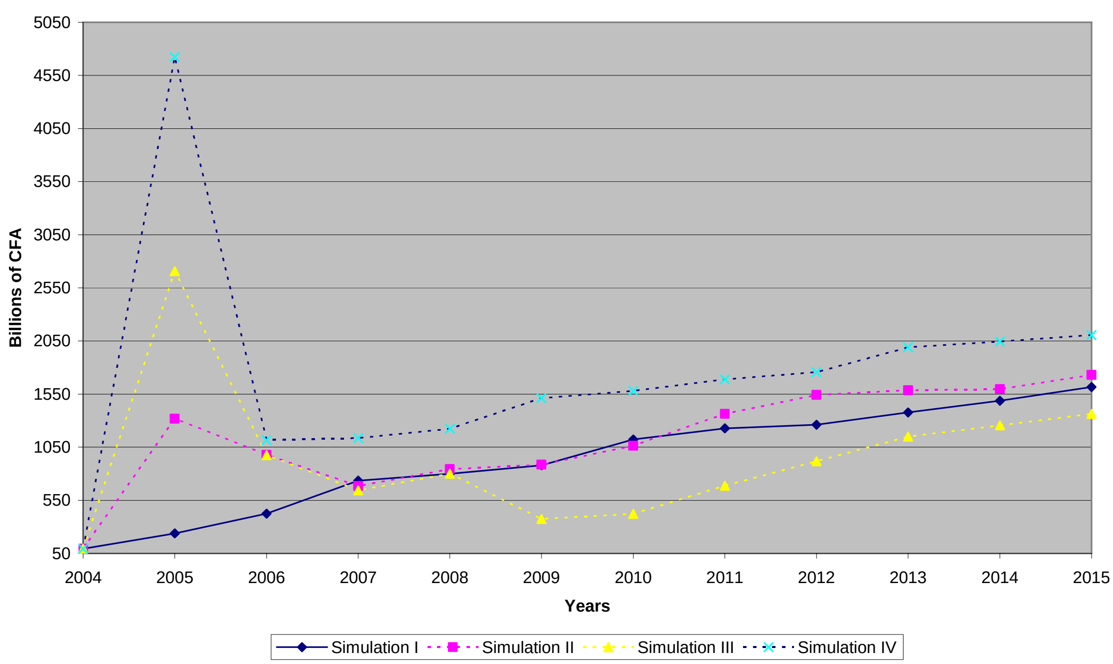


Figure 26
The Impact of Mix Investment: Unskilled Household Total Consumption

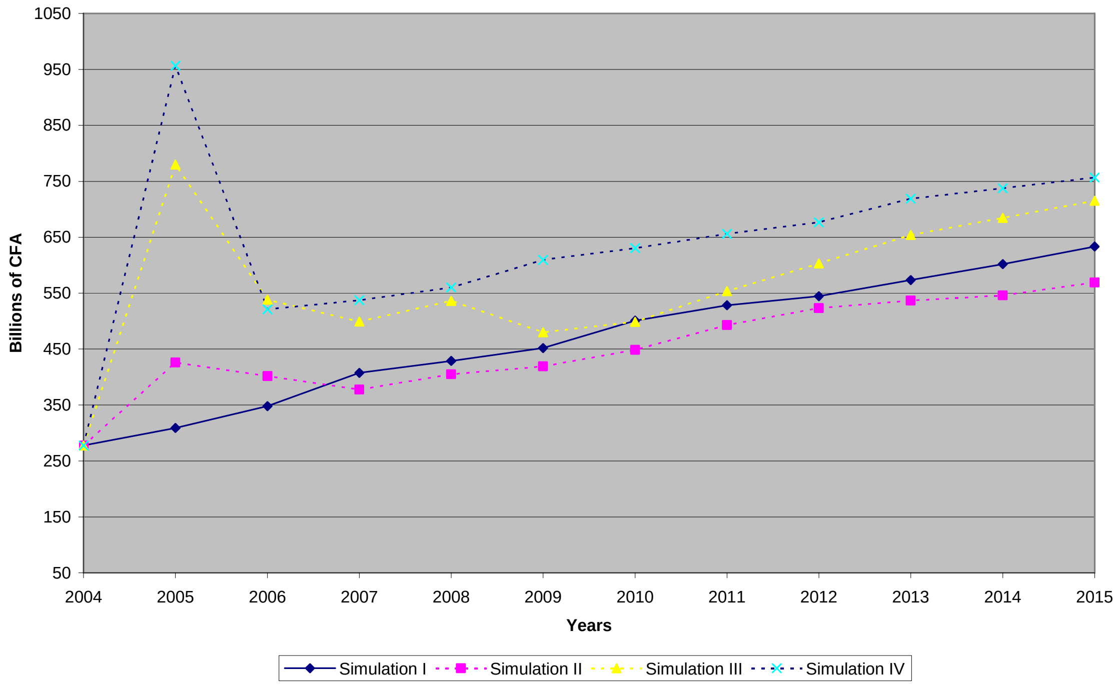


Figure 27
The Impact of Mix Investment: Informal Household Total Consumption

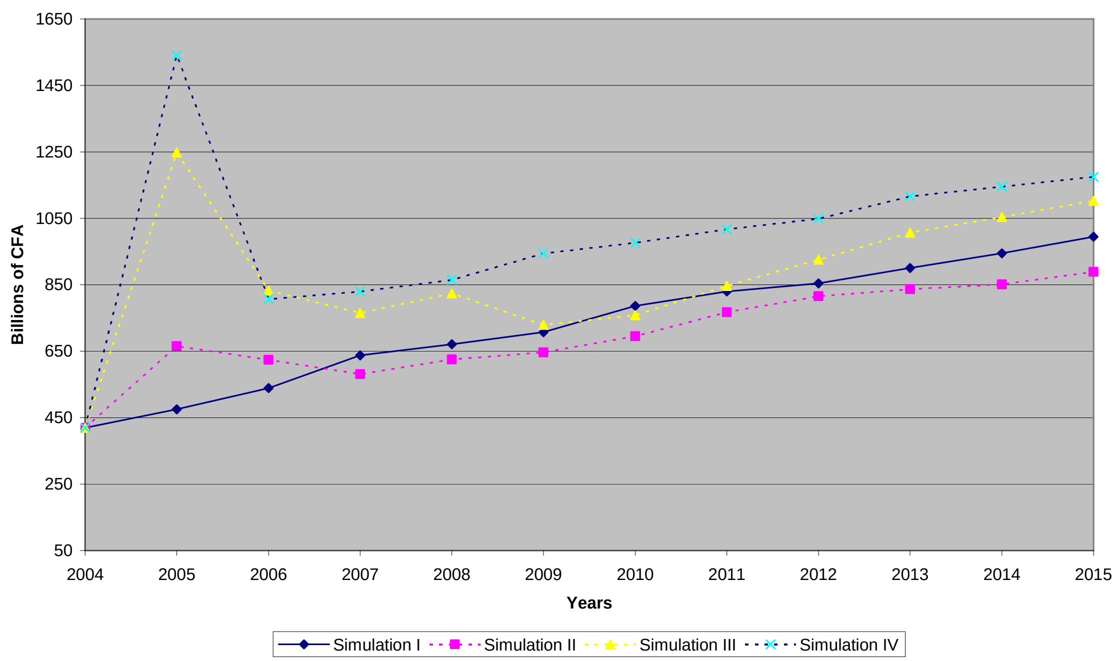


Figure 28
The Impact of Mix Investment: Capitalist Household Total Consumption

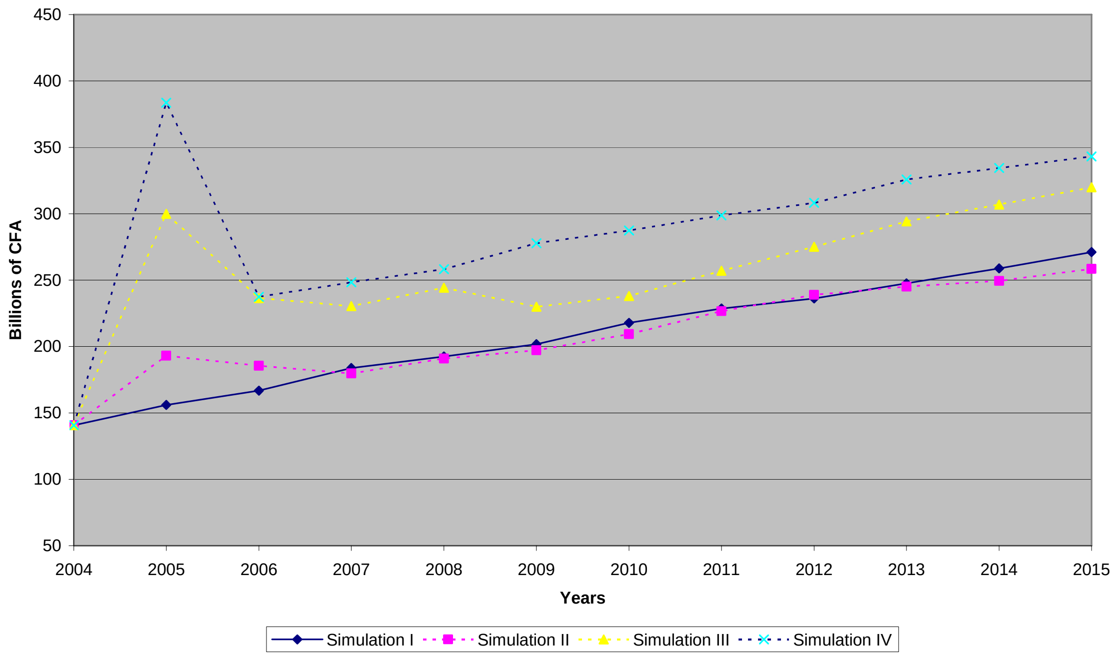
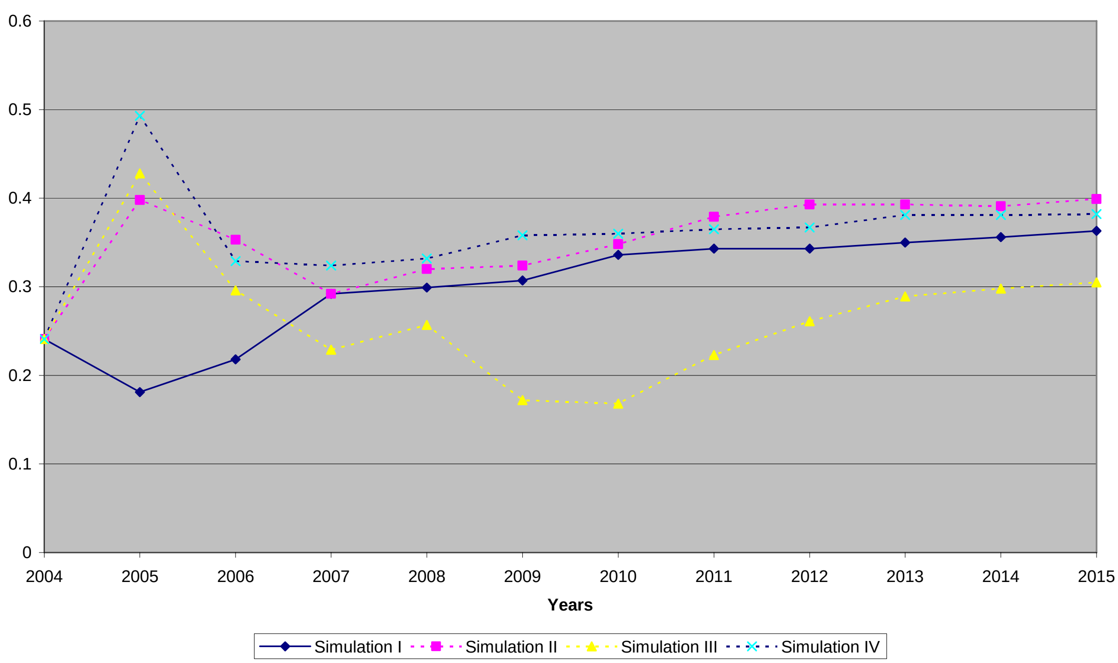


Figure 29
The Impact of Mix Investment: Gini Coefficient



Welfare Impact of Investment Strategies

Table 26 shows the welfare impact of different investment strategies using equivalent variation as a measure. Overall, the welfare of all the representative households improves regardless of which investment strategy is adopted. Moreover, skilled households experience a greater improvement in welfare, primarily because of the increase in skilled wages mentioned previously. However, skilled household welfare decreases in Simulation III relative to Simulation I.

Agricultural households, unskilled households, informal households, and capitalist households see an improvement in their welfare in Simulations III and IV compared to Simulation I. But they experience a relative decrease in welfare when the natural resource windfall is invested in education. This decrease is due to the shrinkage of unskilled labor income, the major source of income for these households, in Simulation II compared to Simulation I.

Table 26: Welfare Impact of Windfall: 12 Years Average of Equivalent Variation

	Agricultural Household	Skilled Household	Unskilled Household	Informal Household	Capitalist Household
Simulation I	45.01	217.76	33.49	48.47	10.93
Simulation II	35.74	226.47	27.66	40.12	9.79
Simulation III	58.96	189.28	46.02	66.39	15.24
Simulation IV	66.62	298.62	52.41	76.71	17.53

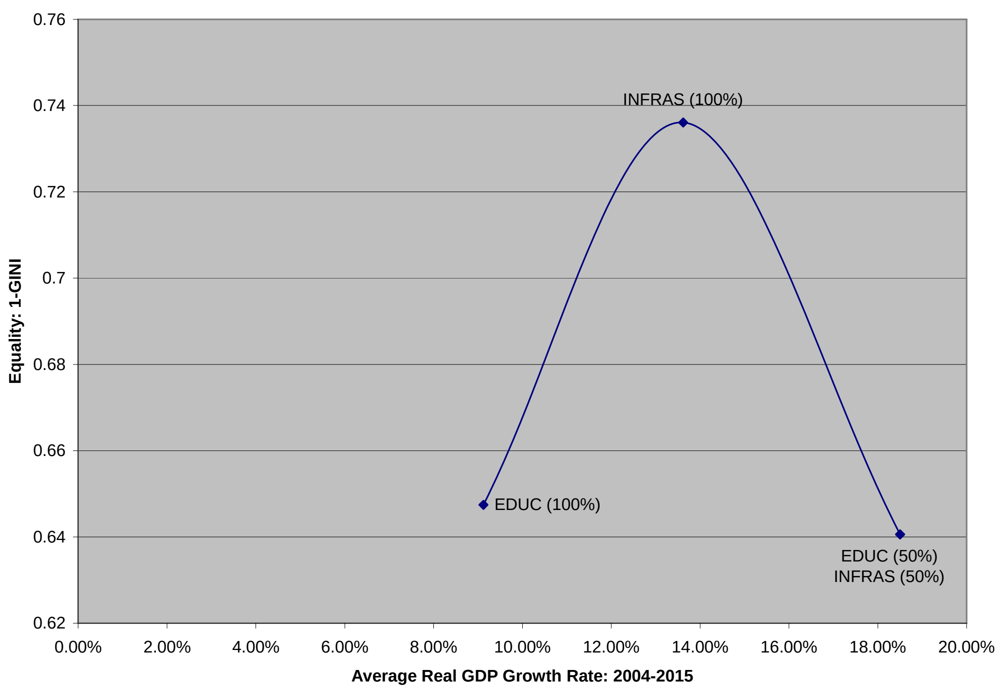
Policy Trade-Offs

In this section, policy trade-offs are quantified with respect to growth and Gini coefficient. Table 27 shows the average growth rate over twelve years of real GDP and the Gini coefficient under Simulations II through IV. The highest growth rate is obtained in Simulation IV, whereas the lowest growth rate is obtained in Simulation III. However the higher growth rate comes with higher income inequality because Simulation IV also has the highest Gini coefficient. This result implies that if policy makers are more concerned about growth than inequality, Simulation IV is the best policy option. The lowest Gini coefficient is obtained in Simulation III.

Table 27: Average Growth Rate of Real GDP and Gini coefficient

	Simulation II	Simulation III	Simulation IV
Growth of GDP	9.12%	13.62%	18.50%
Gini coefficient	6.27%	6.08%	7.88%

Figure 30 : Policy Trade-offs



CONCLUSION

In this chapter, three simulations were performed in order to analyze the impact of the use of natural resource revenues in Niger. The first simulation (II) assumes that natural resource revenues are invested in education, whereas in the second simulation

(III) the windfalls are used for infrastructure investment. In the last simulation (IV), the windfalls are used for both education and infrastructure investment.

The simulation results show that the economic performance is better when the natural resource windfall is invested in education or in infrastructure. However, superior results are obtained when the windfalls are simultaneously invested in education and infrastructure, which implies a complementary effect between the two investment strategies.

CHAPTER VII

CONCLUSION AND POLICY IMPLICATIONS

SUMMARY

Niger has been consistently classified as one of the poorest nations in the world, even though the country has abundant natural resources. In fact, empirical studies have shown that countries that have natural resource export revenues as a main source of foreign exchange earnings tend to grow more slowly than countries that do not. This is known in general terms as the resource curse hypothesis. Although there are many channels through which natural resource revenue can negatively affect the economy, the Dutch disease channel is by far the most important one. The major challenge that faces countries expecting a natural resource windfall like Niger is how to escape the Dutch disease problem.

This study developed a dynamic computable general equilibrium model first to investigate the impact of a natural resource windfall on Niger's economy and second to quantify the effect of three specific uses of the windfall: investment in education, investment in infrastructure, and mixed investment in both. To capture the socio-economic impact from natural resource windfall and investment policies, the study considered the impact on real GDP, consumer price index (CPI), household welfare, and income distribution (the Gini coefficient). The main findings are as follows.

First, a natural resource windfall turns out to significantly increase the overall level of real GDP. Based on the simulation, there are two possible reasons for this result. The first reason is that half of the windfall is saved by the government, which substantially increases public saving. Second, households also save part of the transfer received from the government, which increases private saving. These two effects substantially increase total saving, thereby increasing sharply the capital stock and thus real GDP. Moreover, household income increases significantly, which translates to higher consumption and therefore a welfare improvement. However, the increase in income is not evenly distributed, which explains the relative increase in the Gini coefficient.

Regarding the CPI, this study finds that the overall price level increases but not the long-run inflation rate. This is primarily due to spending effects. This result is very interesting because it shows some indication of Dutch disease.

The second part of the study focuses on experimenting with three investment strategies which the government may adopt in order to avoid the Dutch disease observed in Simulation I and possibly have a greater impact on real GDP. These three investment strategies are investment in education (Simulation II), investment in infrastructure (Simulation III), and simultaneous investment in education and infrastructure (Simulation IV). First, in the case of Simulation II, investment in education creates more skilled labor in the economy, increasing the level of real GDP relative to Simulation I. Moreover, the increase in CPI observed in Simulation I is reversed in Simulation II, implying that education investment reduces the risk of Dutch disease. Of the five household groups, only skilled household income increases in Simulation II relative to Simulation I reflecting the bias of education investment. The Gini coefficient also increases as a result of this uneven income distribution.

Secondly, investment in infrastructure appears to have many positive effects on the economy. It increases real GDP and lowers, on average, the CPI. The remarkable result of the simulation is that investment in infrastructure improves the welfare of all household groups without raising the Gini coefficient index.

Finally, Simulation IV considers a situation where the government invests the windfall in both education and infrastructure. The results are superior to those obtained in the previous simulations. Real GDP is higher, household welfare increases substantially, and the CPI is relatively low compared to Simulation I. However income inequality increases slightly in comparison to the other simulations.

POLICY IMPLICATION

The variety of the results obtained in this study will be very valuable in helping policy makers in Niger reduce if not escape the Dutch disease problem which affects many natural resource exporting countries. The government of Niger should definitely consider spending a big share of the natural resource windfall on education and infrastructure, considering the poor infrastructure and the high rate of unskilled labor in the country. In this regard, Niger’s government has recently announced that it will invest more than 12 billion CFA to reduce its dependency on foreign energy. In addition, the government has secured funds for the Kandadji project, which will allow the country to produce its own electricity and irrigation schemes to reduce the risks associated with climate variability. Moreover, the results of this model can be valuable for any countries that are facing an inflow of capital or foreign exchange gifts.

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APPENDICES

APPENDIX A - LIST OF EQUATIONS (the complete model)

1. Price

$$PM_{it} = \overline{pw_i}(1+tm_i)ER \quad \text{A1}$$

$$PWE_{it} = \frac{PD_{it}}{(1+te_i)ER} \quad \text{A2}$$

$$PQ_{it} = \frac{[PM_{it}M_{it} + D_{it}PD_{it}]}{Q_{it}} \quad \text{A3}$$

$$PV_{it} = PD_{it}(1-tau) - \sum_j PQ_{jt}a_{ij} \quad \text{A4}$$

$$CPI_{it} = \sum_{i=1}^{n} fc_i PQ_{it} \quad \text{A5}$$

2. Production

$$V_{it} = \sum_j a_{ij} X_{it} \quad \text{A6}$$

$$X_{it} = VA_{it} + V_{it} \quad \text{A7}$$

$$VA_{it} = TFPR * A_{it} LUS_{it}^{\alpha_{1i}} LS_{it}^{\alpha_{2i}} K_{it}^{1-\alpha_{1i}-\alpha_{2i}} \quad \text{A8}$$

$$TFPR = \lambda_{TFPR} * (GIFINV * GrowthIF)^{\mu} \quad \text{A9}$$

$$E_{it} = D_{it}\left[\left(\frac{PWE_{it}}{PD_{it}}\right)\left(\frac{1-\lambda_{ed}}{\lambda_{ed}}\right)\right]^{\sigma_{ed}} \quad \text{A10}$$

$$M_{it} = D_{it}\left[\left(\frac{PM_{it}}{PD_{it}}\right)\left(\frac{1-\lambda_Q}{\lambda_Q}\right)\right]^{\sigma_Q} \quad \text{A11}$$

$$Q_{it} = A_Q\left[\lambda_Q M_{it}^{-\rho_Q} + (1-\lambda_Q)D_{it}^{-\rho_Q}\right]^{\frac{-1}{\rho_Q}} \quad \text{A12}$$

$$Fsav_t = \sum_i PM_{it}M_{it} - \sum_i PWE_{it}E_{it} \quad \text{A13}$$

3. Labor Market

$$PV_{it}\frac{\partial X_{it}}{\partial LU_{it}} = WUS_{it} \qquad \text{A14}$$

$$PV_{it}\frac{\partial X_{it}}{\partial LS_{it}} = WS_{it} \qquad \text{A15}$$

$$LUS_{it}^{D} = LUS_{it}^{S} \qquad \text{A16}$$

$$LS_{it}^{D} = LS_{it}^{S} \qquad \text{A17}$$

4. Income

$$YLS_{t} = \sum_{i} WS_{it}LS_{it} \qquad \text{A18}$$

$$YLUS_{t} = \sum_{i} WUS_{it}LUS_{it} \qquad \text{A19}$$

$$YK_{i} = \sum_{i}\left(PV_{it}X_{it} - WS_{it}LS_{it} - WUS_{it}LUS_{it}\right) \qquad \text{A20}$$

$$\begin{aligned} Hinc_{ht} = {} & (YLS_{t}HFSH_{1} + YLUS_{t}HFSH_{2} + YK_{t}HFSH_{3} \\ & + WTH * ER + GTH) * (1-t) \end{aligned} \qquad \text{A21}$$

$$\begin{aligned} YG_{t} = {} & \sum_{h} Hinc_{h} * t + \sum_{i} X_{it} * tau_{i} + \sum_{i} M_{it} * tm \\ & + \sum_{i} X_{it} * tex + WTG * ER \end{aligned} \qquad \text{A22}$$

5. Expenditure

$$CH_{it,h} = \gamma_{it,h} + \frac{\beta_{i,h}}{PQ_{it}}\left[\left(Hinc_{t,h} - Hsav_{t,h}\right) - \sum_{j} PQ_{j}\gamma_{j,h}\right] \qquad \text{A23}$$

$$Gcom_{it} = \frac{gcfc_{i} * GC_{it}}{PQ_{it}} \qquad \text{A24}$$

$$TC_{it} = \sum_{h} CH_{it,h} + Gcom_{it} \qquad \text{A25}$$

$$G\exp_{t} = \sum_{i} PQ_{it}Gcom_{it} + GTH * CPI + GTW * ER \qquad \text{A26}$$

6. Saving-Investment

$$Hsav_{ht} = MPS_H * Hinc_H \quad \text{A27}$$

$$GS_t = YG_t - G\exp_t \quad \text{A28}$$

$$TS_t = \sum_h Hsav_{ht} + GS_t + Fsav_t * ER \quad \text{A29}$$

7. Macroeconomics

$$GDP_t = YLS_t + YLUS_t + YK_t + YG_t - (Fsav_t - \overline{WTG} - \overline{WTH}) * ER \quad \text{A30}$$

$$RGDP_t = \frac{GDP_t}{CPI_t} \quad \text{A31}$$

$$Exp\inf_t = {100 * (CPI - CPI_o)} \big/ {CPI_o} \quad \text{A32}$$

$$R_t = No\min t_t - Exp\inf_t \quad \text{A33}$$

$$PA_t = {GDP_t} \big/ {RGDP_t} \quad \text{A34}$$

8. Investment and Dynamics

$$Z_{it} = H_{it} \frac{TS_t}{U_{it}} \quad \text{A35}$$

$$Zo_{it} = \sum_j s_{ij} Z_{jt} \quad \text{A36}$$

$$H_{i,t-1} = SP_{i,t-1} + SP_{i,t-1}\left(\frac{R_{i,t-1} - AR_{t-1}}{AR_{t-1}}\right) \quad \text{A37}$$

$$R_{it} = \frac{YK_{it}}{U_{i,t-1}K_{i,t-1}} \quad \text{A38}$$

$$Yk_t = \sum_i Yk_{it} \quad \text{A39}$$

$$SP_{it} = \frac{Yk_{it}}{Yk_t} \quad \text{A40}$$

$$AR_t = \sum_{i=1}^{n} SP_{it} R_{it} \qquad \text{A41}$$

$$U_{it} = \sum_{j=1}^{n} s_{ji} PQ_{ji} \qquad \text{A42}$$

$$K_{i,t+1} = K_{0,it} + Z_{it} \qquad \text{A43}$$

9. Labor Dynamic

$$LF_{i,t+1} = (1+n) LF_{it} \qquad \text{A44}$$

$$LS_{i,t+1} = LS_{it} + Educ * ShareED_i \qquad \text{A45}$$

$$Educ = eff .* Enr \qquad \text{A46}$$

$$Eff = \lambda_{ed} * (GHCINV * GrowthHC)^{\mu_{ed}} \qquad \text{A47}$$

$$LUS_{i,t+1} = LF_{i,t+1} - LS_{i,t+1} \qquad \text{A48}$$

10. Welfare and Income Distribution

$$Gini = \frac{1}{2n^2 Hincbar} \sum_i \sum_j \left| Hinc_i - Hinc_j \right| \qquad \text{A49}$$

$$Theil = \frac{1}{n} \sum_h \frac{Hinc_h}{Hincbar} \log\left(\frac{Hinc_h}{Hincbar} \right) \qquad \text{A50}$$

$$EV_{ht} = \prod_i \frac{PQ_{o,it}}{PQ_{it}} Hinc_h - Hinc_{o,h} \qquad \text{A51}$$

Variables Name and Definitions

Endogenous Variable

Names	Definitions
PM_{it}	Import Prices
Pwe_{it}	Export Prices
PD_{it}	Domestics Prices
PQ_{it}	Composite Prices
Q_{it}	Composite Goods
M_{it}	Imports
D_{it}	Domestic Output
PV_{it}	Value Added Prices
CPI_{it}	Consumer Price Indices
V_{it}	Intermediate Inputs
X_{it}	Total Output
VA_{it}	Value Added
LUS_{it}	Unskilled Labor
LS_{it}	Skilled Labor
E_{it}	Export
F_{t}	Inflow of Foreign Capital
WUS_{it}	Unskilled Wage Rate

WS_{it}	Skilled Wage Rate
YLS_t	Skilled Wage
$YLUS_t$	Unskilled Wage
Yk_t	Capital Income
$Hinc_{ht}$	Household Income
Yg_t	Government Income
$CH_{it,h}$	Household Consumptions
$Hsav_{t,h}$	Household Saving
$Gcom_{it}$	Government Consumption
TC_{it}	Total Consumption
$G\exp_t$	Government Expenditure
GS_t	Government Saving
TS_t	Total Saving
GDP_t	Gross Domestic Product (Nominal)
$RGDP_t$	Gross Domestic Product (Real)
PA_t	Average Price
$Exp\inf_t$	Expected Inflation
R_t	Real Interest Rate
Z_{it}	Investment By Sector of Destination
Zo_{it}	Investment By Sector of Origin

U_{it}	Vector of Capital Prices
$H_{i,t+1}$	Sectoral Profit Share at t+1
SP_{it}	Sectoral Share in Aggregate Profit
AR_t	Average Profit Rate
$LS_{i,t+1}$	Skill Labor Supply at time t+1
$Educ$	Educated Labor
eff	Efficiency of Educated Labor
$LUS_{i,t+1}$	Unskill Labor Supply at time t+1
$Gini$	Gini Coefficient
$Theil$	Theil Inequality Index
EV_{ht}	Equivalent Variations
$HincBar$	Household Mean Income

Exogenous Variable

Names	**Definitions**
$\overline{PW}$	World Price of Import
tm_i	Import Tax
ER	Fix Exchange Rate
te_i	Export Subsidy
a_{ij}	Input Output Coefficient

tau_i	Indirect Tax
fc_i	Sectoral Consumptions Shares
$TFPR * A_i$	Total Factor Productivity
α_{1i}	Share of Unskilled Labor
α_{2i}	Share of Skilled Labor
λ_{TFPR}	TFPR Shift Parameters
$GIFINV$	Government Infrastructure Investment
GrowthIF	Growth Rate of GIFINV
μ	Effectiveness of GIFINV
λ_{ed}	Share Parameter in Export Function
σ_{ed}	Export Substitution Parameters
λ_Q	Share Parameter in Import Function
σ_Q	Argminton Parameters
ρ_Q	Elasticity of Substitution
A_Q	Composite Goods Shift Parameter
$HFSH_{1,2,3}$	Household Factor Income Share
WTH	World Transfer to Household
GTH	Government Transfer to Household
t	Direct Tax Rate
tex	Export Tax
WTG	World Transfer to Government

$\gamma_{it,h}$	Committed Expenditure
$\beta_{i,h}$	Marginal Budget Shares
$gcfc_i$	Government Consumption Share
GTW	Government Transfer to World
MPS_h	Marginal Propensity to Save
$Fsav$	Foreign Saving
PDo_i	Base Year Domestic Prices
$CPIo_i$	Base Year Consumer Price Index
$No\min t$	Nominal Interest Rate
S_{ij}	Capital Composition Matrix
LF_{it}	Labor Force
n	Growth Rate of Labor Force
$ShareED_i$	Sectoral Share of Skilled Labor
Enr	Gross Enrollment
λ_{hc}	Human Capital Shift Factor
$GHCINV$	Government Human Capital Investment
GrowthHC	Growth Rate of GHCINV

APPENDIX B – Statistical Data

Table B-1
MACRO SOCIAL ACCOUNTING MATRIX 2004 – Niger (IN BILLION OF CFA)

Revenus → Dépenses ↓	Branches	Produits	Facteurs de production	Ménages et Entreprises individuelles	Gouvernement	Taxes Directes	Impôts sur la production
Branches		1 315,5		214,6			
Produits				1 162,3	201,6		
Facteurs de production	1 504,5						
Ménages et Entreprises individuelles			1 497,5		38,2		
Gouvernement						34,2	25,7
Taxes Directes				34,2			
Impôts sur la production	25,7						
Taxes nettes sur la production		83,9					
Taxes sur les importations		7,4					
Taxes sur les exportations		8,1					
Autres Taxes Indirectes							
Epargne Investment				139,6	29,2		
Reste du Monde		413,6	7,0		8,1		
Total Revenus	1 530,2	1 828,6	1 504,5	1 550,7	218,7	34,2	25,7

Source : Institut National de la Statistiques

Table B-1 (continued)

Revenus → Dépenses ↓	Taxes nettes sur la production	Taxes sur les importations	Taxes sur les exportations	Autres Taxes Indirectes	Epargne Investment	Reste du Monde	Total Revenus
Branches							1530,2
Produits				83,237	133,3	248,2	1828,6
Facteurs de production							1504,5
Ménages et Entreprises individuelles						15,0	1550,7
Gouvernement	83,9	7,4	8,1			59,4	218,7
Taxes Directes							34,2
Impôts sur la production							25,7
Taxes nettes sur la production							83,9
Taxes sur les importations							7,4
Taxes sur les exportations							8,1
Autres Taxes Indirectes					83,2		83,2
Epargne Investment						106,0968	216,5
Reste du Monde							428,7
Total Revenus	83,9	7,4	8,1	83,2	216,5	428,7	

Source : Institut National de la Statistiques

Table B-2: SAM Table for Niger (2004) Inter-Industry Transactions (Billion of CFA)

SECTOR	AGRICULUTRE	MINING	MANUFACTURING	UTILITY	CONTRUCTION
AGRICULUTRE	18.07		57.93		
MINING	0.00	4.25	10.09	1.10	6.33
MANUFACTURING	31.53	6.05	70.43	5.63	24.46
UTILITY	1.15	4.46	6.28	3.77	3.13
CONTRUCTION		0.04	0.02		1.59
TRADE	10.85	1.82	0.12		3.59
TRANSPORTATION	0.04	3.15	17.68	0.66	1.79
FINANCE		11.67	2.72	4.13	8.45
SERVICES	1.48		0.01		0.00
TOTAL INTERMEDIATE	63.12	31.44	165.28	15.30	49.36

Source : Institut National de la Statistiques

Table B-2 (continued)

SECTOR	TRADE	TRANSPORTATION	FINANCE	SERVICES	TOTAL INTERMEDIATE
AGRICULUTRE	9.35				85.34
MINING		17.20	0.07	2.86	41.90
MANUFACTURING	18.82	5.05	1.10	24.60	187.69
UTILITY	1.71	0.05	1.08	5.78	27.41
CONTRUCTION	0.01	0.05	0.08		1.79
TRADE	1.29	17.02	0.02	20.44	55.14
TRANSPORTATION	6.81	0.88	0.22	16.75	47.98
FINANCE	7.40	4.10	3.28	4.78	46.54
SERVICES	0.00	0.00		0.01	1.50
TOTAL INTERMEDIATE	45.38	44.36	5.84	75.22	495.00

Source : Institut National de la Statistiques

Table B-3 : SAM Table for Niger (2004) Structure of Final Demand (Billion of CFA)

SECTOR	Household AGRIC	Household SK	Household UK	Household INFO	Household CAP	GOV	SAVINV
AGRICULUTRE	229.72	21.52	122.64	150.40	54.85	0.00	18.51
MINING	13.44	6.94	10.51	15.04	4.73	0.00	7.00
MANUFACTURING	115.04	29.90	75.01	90.09	39.63	0.00	65.71
UTILITY	12.86	5.48	7.63	9.39	7.69	0.00	4.26
CONTRUCTION	2.73	0.18	1.42	2.46	0.42	0.00	92.45
TRADE	23.92	9.04	26.08	103.57	8.00	0.00	0.00
TRANSPORTATION	8.71	7.49	8.79	17.58	5.43	0.00	0.00
FINANCE	36.24	8.10	23.11	28.68	14.25	0.00	8.96
SERVICES	8.71	4.33	2.73	1.86	5.75	192.87	26.30
TOTAL	**451.36**	**92.98**	**277.92**	**419.09**	**140.76**	**192.87**	**223.17**

Source : Institut National de la Statistiques

Table B-3 (continued)

SECTOR	EXPORT	IMPORT	MTAX	ETAX	ITAX	Final Demand
AGRICULUTRE	76.62	55.11	14.50	5.41	0.60	**598.65**
MINING	143.76	61.06	14.38	0.17	0.26	**125.53**
MANUFACTURING	23.94	270.78	48.63	1.83	1.20	**116.88**
UTILITY		26.62	6.26		5.82	**8.62**
CONTRUCTION					0.03	**99.62**
TRADE					0.09	**170.53**
TRANSPORTATION	3.89	3.18	0.09		0.00	**48.61**
FINANCE					0.16	**119.19**
SERVICES						**242.55**
TOTAL	**248.20**	**416.75**	**83.86**	**7.41**	**8.15**	

Source : Institut National de la Statistiques

Table B-4 : SAM Table for Niger (2004) Value Added (Billion of CFA)

SECTOR	AGRICULUTRE	MINING	MANUFACTURING	UTILITY	CONTRUCTION
UNSKILLED WAGES	566.07	116.54	119.80	5.29	48.32
SKILLED WAGES		17.11	5.88	14.63	1.21
CAPITAL	47.81	2.00	2.73	0.10	0.78
VA TAX	7.00	0.34	10.88	0.71	1.75
TOTAL VAD	**620.87**	**135.98**	**139.29**	**20.73**	**52.06**

Source : Institut National de la Statistiques

Table B-4 (continued)

SECTOR	TRADE	TRANSPORTATION	FINANCE	SERVICES	Total VAD
UNSKILLED WAGES	169.22	40.24	136.25	47.90	**1249.62**
SKILLED WAGES	1.17	4.07	12.31	119.39	**175.78**
CAPITAL	9.08	6.99	11.23	1.56	**82.26**
VA TAX	0.81	0.93	0.10		**22.51**
TOTAL VAD	**180.29**	**52.23**	**159.88**	**168.84**	

Source : Institut National de la Statistiques

Table B-5 : Labor Force by Sector and Skill (2004)

Sector	Unskilled Labor	Skilled Labor
AGRICULUTRE	3,149,089	0
MINING	5,641	230
MANUFACTURING	91,119	1,657
UTILITY	992	1,554
CONTRUCTION	12,477	785
TRADE	502,319	3,336
TRANSPORTATION	24,562	1,284
FINANCE	1,843	188
SERVICES	59,155	92,705
Total	3,847,196	101,739

APPENDIX C

ESTIMATED DATA AND PARAMETER

Table C-1
Production Function Parameters (2004)

Sector	AVA	alphaU	alphaS	alphaK
AGRICULUTRE	0.0003	0.9221	0.0000	0.0779
MINING	0.0322	0.8592	0.1261	0.0147
MANUFACTURING	0.0035	0.9329	0.0458	0.0213
UTILITY	0.0193	0.2642	0.7308	0.0050
CONTRUCTION	0.0071	0.9604	0.0241	0.0155
TRADE	0.0005	0.9428	0.0065	0.0506
TRANSPORTATION	0.0060	0.7844	0.0793	0.1363
FINANCE	0.1331	0.8527	0.0770	0.0703
SERVICES	0.0023	0.2837	0.7071	0.0092

Table C-2
Sectoral Import Tariff, Export Tax, and Export Subsidy Rate (2004)

SECTOR	tm	tex	te
AGRICULUTRE	0.26311	0.008787	0
MINING	0.235506	0.002568	0
MANUFACTURING	0.179592	0.009948	0
UTILITY	0.235162	0.161577	0
CONTRUCTION	0	0.000296	0
TRADE	0	0.000399	0
TRANSPORTATION	0.028302	0	0
FINANCE	0	0.000965	0
SERVICES	0	0	0

Table C-3
Estimated Value (Taken From other Studies)

Sector	SigcQ	rhoq	LandaQ
AGRICULUTRE	1.5	2	0.000676
MINING	1.5	2	0.799693
MANUFACTURING	2	1	0.399055
UTILITY	2	1	0.234396
CONTRUCTION	1.5	2	0
TRADE	2	1	0
TRANSPORTATION	2	1	0.001173
FINANCE	2	1	0
SERVICES	2	1	0

Table C-4
Estimate Value of Income Elasticities and Frisch Parameter (Taken from other Studies)

	Households Groups				
Sector	Agricultural	Skilled	Unskilled	Informal	Capital
AGRICULUTRE	0.889	0.669	0.88	0.859	0.82425
MINING	0.409	0.879	0.42	0.399	0.52675
MANUFACTURING	1.159	1.119	1.14	1.119	1.13425
UTILITY	1.159	1.119	1.14	1.119	1.13425
CONTRUCTION	1.159	1.119	1.14	1.119	1.13425
TRADE	1.159	1.119	1.14	1.119	1.13425
TRANSPORTATION	1.159	1.119	1.14	1.119	1.13425
FINANCE	1.159	1.119	1.14	1.119	1.13425
SERVICES	1.159	1.179	1.14	1.119	1.14925
FRISCH PARAMETER	-4	-4	-5	-5	-4.5

Table C-6
Calibrated Value of Marginal Expenditure Share

	Household Groups				
Sector	Agricultural	Skilled	Unskilled	Informal	Capital
AGRICULUTRE	0.452457	0.15485	0.388335	0.308281	0.321216
MINING	0.0121777	0.06556	0.015884	0.014316	0.017707
MANUFACTURING	0.2953981	0.35986	0.307704	0.240548	0.319355
UTILITY	0.0330324	0.06601	0.031281	0.025083	0.061988
CONTRUCTION	0.006999	0.00214	0.005815	0.006577	0.003378
TRADE	0.0614242	0.10876	0.106971	0.276549	0.064495
TRANSPORTATION	0.0223571	0.09018	0.036038	0.046939	0.043726
FINANCE	0.0930464	0.09752	0.094804	0.076591	0.114834
SERVICES	0.0223607	0.05485	0.011205	0.004974	0.046933

Table C-5
Calibrated Value of "Subsistence Minima"

	Household Groups				
Sector	Agricultural	Skilled	Unskilled	Informal	Capital
AGRICULUTRE	178.6647	17.92078	101.0554	124.5613	44.80331
MINING	12.06576	5.414935	9.62716	13.83981	4.176327
MANUFACTURING	81.70716	21.53548	57.90772	69.92786	29.64104
UTILITY	9.133815	3.94697	5.89036	7.288518	5.751693
CONTRUCTION	1.938983	0.129645	1.09624	1.909452	0.314137
TRADE	16.98918	6.51106	20.13376	80.39103	5.983556
TRANSPORTATION	6.186278	5.394673	6.78588	13.6456	4.061338
FINANCE	25.73946	5.834025	17.84092	22.26142	10.65821
SERVICES	6.186278	3.053733	2.10756	1.443732	4.281514

APPENDIX D – COMPUTER CODE

Gauss Program

(The Complete Model)

```
/*--------------load data and set parameter values-------------*/

               @ calculation of input-output coefficients
              ============================================= @

  @ Inter-industry transactions @

    let Xij[9,9]=
              18.07 0.00 57.93 0.00 0.00 9.35  0.00 0.00 0.00
               0.00 4.25 10.09 1.10 6.33 0.00  17.20 0.07 2.86
               31.53 6.05 70.43 5.63 24.46 18.82 5.05 1.10 24.60
               1.15 4.46 6.28 3.77 3.13 1.71 0.05 1.08 5.78
               0.00 0.04   0.02 0.00 1.59 0.01 0.05 0.08 0.00
               10.85 1.82 0.12 0.00 3.59 1.29 17.02 0.02 20.44
               0.04 3.15 17.68 0.66 1.79 6.81 0.88 0.22 16.75
               0.00 11.67 2.72 4.13 8.45 7.40 4.10 3.28 4.78
               1.48 0.00   0.01 0.00 0.00 0.00 0.00 0.00 0.01;
  @ net final demand @

    let NFD[9,1] = 598.65  125.53 116.88 8.62
       99.62  170.53 48.61  119.19 242.55;

 @ Sectorsl Investment Expenditure, Billions XOF @

    Let SAVINV[9,1]=12.64 4.66 47.07 0.00 67.08
     0.00 0.00 5.82 2.66; @ PRIVATE INVESTMENT @

    LET GINV[9,1] = 5.87 2.34 18.63 4.26 25.37
    0.00 0.00 3.14 23.64; @ GOVERNMENT INVESTMENT @

    Z = SAVINV + GINV;
```

```
/*-------------------Household-----------------------------*/

@ Comsumptions Data@

Let HA[9,1]=229.72  13.44  115.04 12.86
              2.73  23.92  8.71   36.24  8.71;

Let HS[9,1]=21.52   6.94   29.90  5.48
             0.18   9.04   7.49   8.10   4.33;

Let HU[9,1]=122.64  10.51  75.01  7.63
              1.42  26.08  8.79   23.11  2.73;

Let HI[9,1]=150.40  15.04  90.09  9.39
              2.46  103.57 17.58  28.68  1.86;

Let HC[9,1]=54.85   4.73   39.63  7.69
             0.42   8.00   5.43   14.25  5.75;

Let GC[9,1]=0.00    0.00   0.00   0.00
             0.00   0.00   0.00   0.00   192.87;

              @ Gross Household Income @
Let HincG[5,1]=473.32 175.16 326.87 436.85 144.81;

             @ Household Disposable Income @
Let Hinc[5,1]=469.52 161.02 319.39 434.36 144.09;

            @ Household Disposable Income @
Let Hinc0[5,1]=469.52 161.02 319.39 434.36 144.09;

            @ Household Tax Payment @
let Htax[5,1]=3.80  14.14  7.48   2.49   0.72;

            @ Household Saving @
let Hsav[5,1]=18.17 68.03  41.47  15.27  3.34;

            @Household YWUSK share@
let HFSH1[5,1]= 0.347761404      0.003847813  0.258810322
             0.33986663   0.049713831;
```

```
              @Household YWSK share@
Let HFSH2[5,1]= 0.002955953      0.980233882  0
                0.004561349 0.012248816;

                   @ Household Yk share @
Let HFSH3[5,1]=  0.049377594 0.013460144 0.010936358
                 0.039440596      0.886785308;

         @World Transfer to Household@
Let WTH[5,1] =10.42 0.14 0.49 1.97 1.99;

      @Government Transfer to Household@
Let GTH[5,1] = 23.76 0.57 2.07 6.15 5.65;

/*------ Household Linear Expenditure System Parameters----- */

              @ Frisch Parameters @
Let Frisch[5,1] = -4.00    -4.00  -5.00  -5.00  -4.5;

@ Household Average Budget Shares@

HAfc = HA./Sumc(HA);
@print "Agricultural Household Average Budget Shares";
print HAfc;@

HSfc = HS./Sumc(HS);
@print "Skill Household Average Budget Shares";
print HSfc;@

HUfc = HU./Sumc(HU);
@print "Unskill Household Average Budget Shares";
print HUfc;@

HIfc = HI./Sumc(HI);
@print "Informal Household Average Budget Shares";
print HIfc;@

HCfc = HC./Sumc(HC);
@print "Capitalist Household Average Budget Shares";
print HCfc;@

GCTOT = sumc(GC);
```

```
GCfc = GC./Sumc(GC);
@print "Goverment Consumptions Shares";
print GCfc;@


@ Elasticity of Income @

Let ElastIncHA[9,1]=0.889  0.409  1.159  1.159  1.159
                           1.159  1.159  1.159  1.159;

Let ElastIncHS[9,1]=0.669  0.879  1.119  1.119  1.119
                      1.119      1.119  1.119  1.179;

Let ElastIncHU[9,1]=0.88   0.42   1.14   1.14   1.14
                    1.14   1.14   1.14   1.14;

Let ElastIncHI[9,1]=0.859  0.399  1.119  1.119  1.119
                           1.119  1.119  1.119  1.119;

Let ElastIncHC[9,1]=0.82425      0.52675      1.13425      1.13425
      1.13425
                    1.13425      1.13425      1.13425      1.14925;

@ Formula for Computing the Marginal Budget Shares@

HAms = HAfc.*ElastIncHA;
@print "Agricultural Household Marginal Budget Shares";
print HAms;@

HSms = HSfc.*ElastIncHS;
@print "Skill Household Marginal Budget Shares";
print HSms;@

HUms = HUfc.*ElastIncHU;
@print "Unskill Household Marginal Budget Shares";
print HUms;@

HIms = HIfc.*ElastIncHI;
@print "Informal Household Marginal Budget Shares";
print HIms;@

HCms = HCfc.*ElastIncHC;
```

```
@print "Capitalist Household Marginal Budget Shares";
print HCms;@

@ Computing the Subsistence Minima @

GamaHA = sumc(ha)*(HAfc + hams./(-4));
@print Gamaha;@

GamaHs = sumc(hs)*(Hsfc + hsms./(-4));
@print Gamahs;@

GamaHu = sumc(hu)*(Hufc + hums./(-5));
@print Gamahu;@

GamaHi = sumc(HI)*(Hifc + hims./(-5));
@print Gamahi;@

GamaHc = sumc(HC)*(Hcfc + hcms./(-4.5));
@print Gamahc;@

/*----------Trade Data and Parameters estimate-------------*/

Let E[9,1]=76.62 143.76 23.94 0.00 0.00
            0.00 3.89 0.00 0.00; @ Export in Billion of XOF @

Let M[9,1]=55.11    61.06  270.78 26.62 0.00    0.00
             3.18   0.00   0.00; @ Import in Billion of XOF @

@ value added - payments to factors of production
              plus indirect taxes @
    let VA[9,1] = 620.87   135.98 139.29 20.73
                    52.06  180.29 52.23  159.88 168.84;

  @ indirect taxes @
    let Indtax[9,1] = 7.00 0.34   10.88  0.71
            1.75    0.81   0.93   0.10   0.00;

  @ direct tax@
       Let dtax[5,1]= 3.80 14.14 7.48   2.49 0.72;

 @ Tariff Revenue @
      Let tariffs[9,1]= 14.50 14.38 48.63 6.26 0.00
```

```
                      0.00 0.09 0.00 0.00;

 @ Export Tax@
 Let exptax[9,1] = 6.01    0.43   3.03   5.82
             0.03   0.09   0.00   0.16 0.00;

@ total expenditure @
    X = sumc(Xij) + VA;
 @print "Total Expenditure";
 print X;@

   @ the A matrix @

    A=(Xij'./X)' ;

 @ print "A Matrix";
 print A; @

Let Profits[9,1] = 47.81   2.00   2.73   0.10
             0.78   9.08   6.99   11.23  1.56;

K=Profits./(0.035);
@print "profits";
print K;@

/* --------------------------Tax Rate------------------------ */

tau = indtax./X; @ Indirect Tax Rate@
@print "Indirect Tax Rate";
print tau;@

t =(Htax./HINC); @ Direct Tax Rate@
@print "direct Tax Rate";
print t;@

tm = tariffs[1:4,1]./M[1:4,1] | zeros(2,1)
      |tariffs[7,1]./M[7,1] | zeros(2,1);  @Tariff Rate@
@print "Tariff";
print tm; @/* tm =zeros(9,1); */

tex = exptax./X;
@print " Export Tax";
```

```
print tex;@  /*tex =zeros(9,1); */

@ Export Subsidy Rate@

Let te[9,1]= 0 0 0 0 0 0 0 0 0;

@ Hsav./(Hinc-Hinc.*t); print MPS;
 Marginal Propensity to save @

let MPS[5,1] =0.038699097 0.42249410 0.12984126
               0.035155171 0.023179957;

/*----------- Computing Composite Labor ----------------------*/

 @Unskilled Labor Force by Sector@
Let LUS[9,1]=3149089 5641 91119 992
 12477 502319 24562 1843 59155;

Let LS[9,1]=0.0001 230 1657 1554 785
 3336 1284 188 92705; @ Skilled Labor Force by Sector @

let LF[9,1] = 3149089 5871 92775 2546
 13262 505655 25847 2030 151860; @ Total Labor Force @

/*Let RhoLB[9,1]= 1 1 1 1 1 1 1 1 1;
@ Elastcity of Substitutions Between skill unskilled@

Let landaLB[9,1]= 1.00    0.93   0.97
0.42   0.91   0.98   0.92   0.87   0.42;
 @1.00 0.96 0.98 0.39 0.94 0.99 0.95 0.91 0.39
 Share of Unskilled Labor in the Composite Labor@
                     @1 0.7 0.6 0.3 0.5 0.5 0.5 0.3 0.3@

Let alb[9,1]=1 1 1 1 1 1 1 1 1;
@Shift Parameter of CES skill unskill @

LB = alb.*(landalb.*LUS.^(rholb) +
(1-landalb).*LS.^(rholb)).^(1./(rholb));@CES Skill Unskill@

print "Composite labor";

print LB; */
```

```
let wageUSK[9,1] = 566.07 116.54 119.80 5.29
 48.32 169.22 40.24 136.25 47.90; @ Unskill Wage Bill @

let wageSk[9,1]= 0.00 17.11 5.88 14.63 1.21
 1.17 4.07 12.31 119.39; @ Skilled Wage Bill@

 WUSK= (WageUSK./LUS).*1000000000; @ Unskilled WAGES RATE@
@print "Unskilled Wage Rate";
print WUSK;@

WSK =  (wagesk./LS).*1000000000; @Skill Wage Rate@
@print "skilled Wage Rate";
print WSK;@


LUSD = LUS;
LSD = LS;

/*---------------- VA Prodution Parameters---------------------*/

alphaU = wageUSK./(X-Indtax-SUMC(Xij));
@ print "alphaU "; print alphaU;@

alphaS = wageSK./(X-Indtax-SUMC(Xij));
  @ print "alphaS "; print alphaS;@

alphaK = profits./(VA-Indtax-SUMC(Xij));
@ print "alphaK "; print alphaK;
CT=alphaU+alphaS+alphaK; print ct;@

AVA = X./(lus^(alphaU).*ls^(alphaS).*K^(1-alphaU-alphaS));
 @ print "A VA"; print AVA;@

X= AVA.*(lus^(alphaU).*ls^(alphaS).*K^(1-alphaU-alphaS));
@ print " X"; print X;@
```

```
/* ---------------------Trade Parameters-----------------------*/

Let SigcED[9,1]=1.5 1.5 2 2 1.5 2 2 2 2;

Let SigcQ[9,1]=1.5 1.5 2 2 1.5 2 2 2 2;

Let rhoq[9,1]= 2 2 1 1 2 1 1 1 1; @ CES @

let LandaQ[9,1]=0.00067572148 0.79969282 0.39905533
 0.23439575 0.00000000 0.00000000 0.0011731191
   0.00000000 0.00000000 ; @ Argminton Share Parameter @

Let RhoED[9,1]= 2 2 1 1 2 1 1 1 1; @ CET @

let LandaEd[9,1] = 0.0018138778 0.98116900 0.0051637517
 0.00000000 0.00000000 0.00000000 0.0017544227
 0.00000000 0.00000000 ; @ CET Share Paramaters @

Let AQ[9,1] = 1.0881364  1.7386784 1.9596476
1.7349682 1.0000000 1.0000000 1.0354440
1.0000000 1.0000000  ; @ Composite goods Scaling @

Let Eta[9,1] = 3 3 3 3 3 3 3 3 3;

Let Eo[9,1]=76.62 143.76 23.94 0.00 0.00 0.00
 3.89 0.00 0.00; @ Export in Billion of XOF @

/* -----------------------Initials Prices------------------------*/
PQ = ones(9,1); @ Initial Composite Prices@

PQo =ones(9,1);

lET PV[9,1] =0.90 0.81 0.42 0.56 0.50 0.80 0.53 0.96 0.69;
@ Initial Value added Price (net prices) @

 PD = ones(9,1); @Initial Domestic Prices @
 PDo =ones(9,1);

@0.97497222 0.66952742 0.88737948 0.88755617 1.1342633
1.0028649 1.0237654 1.0169143 1.3746546@
```

```
Pm = ones(9,1); @ Initial import Prices @
let PWbar[9,1] = 0.79169660 0.80938494 0.84775054
0.80961071 1.0000000 1.0000000 0.97247706
 1.0000000 1.0000000; @Import world Prices Indices@

/*-------------------Saving Rate---------------------------------*/

let Hsav[5,1]= 18.17 68.03 41.47 15.27 3.34;

HsavRate =Hsav./(Hinc-Hinc.*t); @ Household Saving Rate @

@print "Household Saving Rate";

print HsavRate;@

GsavRate = -29.21/209.96;

@print "Goverment Saving Rate";

print GsavRate;@

/*---------------------INVESTMENT PARAMETERS--------------------*/

@ Capital Composition Matrix @

LET Sij[9,9]=
0.691603	0	0	0	0	0	0	0	0
0	1	0.0296038	0	0	0	0	0	0
0 0	0.6541838 0.6639025 0.6596965 0.748148
0.66452 0.6639025 0
0	0	0	0	0	0	0	0	0
0.308396 0	0.3162114 0.3360965 0.3403025 0.251851
 0.335479	0.3360965 0
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	1;
@ones(9,9).*(eye(9)*(z./sumc(z)))@
@print "Capital Composition Matrix";
```

```
print Sij;@

@ Sectoral Price of Capital in Previous Period @

Ulag = ones (9,1);

@print "Sectoral Price of Capital in Previous Period";
print Ulag;@

@ Sectoral Investment Shares@

Let H[9,1] =0.082933823 0.031363412 0.29441283 0.019086877
 0.41422107 0 0 0.040145168 0.11783682  @Z./sumc(Z)@;
@print "Sectoral Investment Shares";
print h;@

/*-------------------Misc Parameters---------------------------*/

@Matrix that reduces number of supply and
         demand balance equations@

let df[8,9]=
            1       0      0      0      0      0      0      0      0
            0       1      0      0      0      0      0      0      0
            0       0      1      0      0      0      0      0      0
            0       0      0      1      0      0      0      0      0
            0       0      0      0      1      0      0      0      0
            0       0      0      0      0      1      0      0      0
            0       0      0      0      0      0      1      0      0
            0       0      0      0      0      0      0      1      0;

DC = 186.4; @ Domestic Credit in Billions @

Mlag = 116.14; @ Initial Money Supply Lag by
 one Year in Billions @

CPI = 1; @ CPI Lag by one year @

Let O[9,1]=683.99 167.43 304.57 36.03 101.42 225.67 96.59
      165.72 244.06; @Total Production@
```

```
WTG = 59.4-0.010620684 ; @ World Transfer to Government@

GTW = 8.10; @Government Transfer to World@

GTHTOT = 38.2; @ Total Government Transfer@

Fsav = 106.10;

Kou = 11.95; @ Capital Outflow@

Kin = 180.50;  @Capital Inflow@

Fbar = Kin - kou; @ Net Capital Flow @

ER = 1; @ Exchange Rate @

NOMINT = 0.035; @ NOMINAL INTEREST RATE @

CPIo = 1; @ CPI IN 2003 @

Remit = 164.695; @ Remitances From Natural Resources Export
           in Billions 2005@

GINV =83.24;

GHCINV = 21.6424;

GIFINV =17.4804;

GOTINV = GINV*0.53;

Pa = 1;

nl =0.03; @ Labor force growth Rate @

educ = 10452; @ Educated Labor Force @

let SharED =0.15 0.01 0.15 0.01 0.01 0.15 0.01 0.01 0.5;

dep = 0.02; @ Skill Labor Force Depreciation Rate @
```

```
enr = 23364; @ Primary+Secondary Enrollment (gross) @

eff =0.44735490;  @ eff=educ/enr; print eff;@

landaHC =0.24187507; GrowthHC=1;

yg = 209.97163;

yk = 82.25;

ywusk = 1249.62;

YWSK = 171.93;

TS = 223.17;

U = ones(9,1);

Ulag = ones(9,1);

pwe = ones(9,1);

MPL =2.23536167816648481999414782312 66;

TFPR = 1; MU=0.2; GrowthIF =0.13; landa = 0.84859615;

let TC[9,1]= 579.14 50.65 349.68 43.06 7.20 170.61 47.99 110.39 216.25 ;

Let Htc[9,1]=353.64 50.65 349.68 43.06 7.20 170.61 47.99 110.39 23.38;

fc = HTC./Sumc(HTC); @ TC./SUMC(TC); SECTORAL CCONSUMPTIONS SHARE@

LET Oo[9,1]= 683.99 167.43 304.57 36.03 101.42 225.67 96.59 165.72 244.06;

let spi[9,1]=0.58 0.02 0.03 0.00 0.01 0.11 0.08 0.14 0.02;

let ri[9,1]=0.035 0.035 0.035 0.035 0.035 0.035 0.035 0.035 0.035;

YHbar = sumc(hinc)/5;

@ETC1=  prodc((PQo./PQ)^hams)*(Hinc[1,1]-PQ'Gamaha)
 - (Hinc0[1,1]-PQo'Gamaha);
```

```
 print ETC1;@


 ETC2 =  Ywusk + Ywsk + Yk + Yg - WTG - Sumc(wth)
 - Fsav ;   print ETC2;


/*==========================the cge model==========================*/

#include eqsolve.ext;
#include gauss.ext;
eqsolveset;

 let x0[315,1]=
   683.99 167.43 304.57 36.03 101.42 225.67 96.59 165.72
   244.06                                                    @VA@

   0.90 0.81 0.42 0.56 0.50 0.80 0.53 0.96 0.69            @PV@

   3149089 5641 91119 992 12477 502319 24562 1843 59155  @LUS@

   0.0001 230 1657 1554 785 3336 1284 188 92705            @LS@

   179757 20659458 1314764 5332661 3872726 336878
   1638303 73928378 809737                                 @wusk@

   0 74391304 3548582 9414414 1541401 350719
   3169782 65478723 1287849                                 @WSK@

   1249.62 175.78 82.25 209.97             @Ywusk Ywsk Yk YG@

   469.52 161.02 319.39 434.36 144.09                     @DHINC@

   18.17 68.03 41.47 15.27 3.34                            @Hsav@

   229.72 13.44 115.04 12.86 2.73 23.92 8.71
   36.24 8.71                                             @HAcoM@

   21.52 6.94 29.90 5.48 0.18 9.04 7.49 8.10 4.33      @HScom@

   122.64 10.51 75.01 7.63 1.42 26.08 8.79 23.11 2.73  @HUcom@

   150.40 15.04 90.09 9.39 2.46 103.57 17.58 28.68
   1.86                                                   @Hicom@

   54.85 4.73 39.63 7.69 0.42 8.00 5.43 14.25 5.75     @HCcom@

   0 0 0 0 0 0 0 0 192.87                                  @GcOM@

   579.14 50.65 349.68 43.06 7.20 170.61 47.99
   110.39 216.25                                          @TC@

   239.17 -29.21 223.17                            @Gexp GS TS@

   1 1 1 1 1 1 1 1 1                                       @U@

   12.80 8.94 112.74 0.00 62.39 0.00 0.00 0.00 26.30      @Z@

   1 1 1 1 1 1 1 1 1                                      @PD@

   1 1 1 1 1 1 1 1 1                                      @Pm@
```

```
1 1 1 1 1 1 1 1 1                                   @PWE@

55.11      61.06  270.78 26.62  0.00
0.00       3.18   0.00   0.00                            @M@

76.62 143.76 23.94 0.00 0.00 0.00 3.89 0.00 0.00       @E@

682.99  99.55 603.07 74.73 101.44 225.76 95.97
165.88 244.06                                          @Q@

1 1 1 1 1 1 1 1 1                                     @PQ@

160.55 1 1537.13001 1537.13001
0 3.5  1 1            @Fbar CPI GDP RGDP EXPINF R Pa TFPR@

18.51 7.00 65.71 4.26 92.45 0.00 0.00 8.96 26.30       @Z@

47.81 2.00 2.73 0.10 0.78 9.08 6.99 11.23 1.56       @rki@

0.035 0.035 0.035 0.035 0.035 0.035 0.035
0.035 0.035                                           @ri@

0.58 0.02 0.03 0.00 0.01 0.11 0.08
0.14 0.02  0.03465                                 @Spi AR@

0.59 0.02 0.03 0.00 0.01 0.11 0.08 0.14 0.02      @Hplus1@

1384.5100 64.142857 143.70000 7.1171429 114.73571
259.42857 199.71429 329.81714 70.871429           @Kplus1@

3243562 6047 95558 2622 13660 520825 26622
2091 156416                                      @LFplus1@

0.000110273 254 1827 1714 866 3679
1416 207 102229                                  @LSplus1@

10452 0.44735490                                @Educ eff@

3243562 5794 93731 909 12794 517146
25207 1884 54187                                @LUSplus1@

311.40200  0.24187702  0.044486499      @YHbar Gini Theil@

0 0 0 0 0  ;                          @EVA EVS EVU EVI EVC@
```

```
vf = zeros(rows(x0),1); @ size of this vector is determined from x0 @

proc fsys(x);

            @ set-up variables of model @

local
O, PV, LUSD, LSD, WUSK, WSK , Ywusk, Ywsk, Yk, Yg,

Hinc, Hsav, HAcom, HScom, Hucom, HIcom, HCcom,

Gcom, TC, Gexp, GS, TS, U, Zo, PD, PM, PWE, M, E,

Q, PQ, fbar, CPI, GDP, RGDP, EXPINF, R, Pa, TFPR,
```

```
Z, rki, ri, spi, ar, Hplus1, Kplus1, LFplus1, lsplus1,

educ, eff, LUSplus1, YHbar, Gini, Theil,

EVA, EVS, EVU, EVI, EVC;

O = x[1:9,1];            PV = x[10:18,1];          LUSD = x[19:27,1];
LSD = x[28:36,1];        WUSK = x[37:45,1];        WSK = x[46:54,1];
Ywusk = x[55,1];         Ywsk = x[56,1];           Yk = x[57,1];
Yg =x[58,1];             Hinc = x[59:63,1];        Hsav = x[64:68,1];
Hacom = x[69:77,1];      Hscom = x[78:86,1];       HUcom = x[87:95,1];
Hicom = x[96:104,1];     HCcom = x[105:113,1];     Gcom = x[114:122,1];
TC = x[123:131,1];       Gexp = x[132,1];          GS = x[133,1];
TS = x[134,1];           U = x[135:143,1];         Zo = x[144:152];
PD = x[153:161,1];       Pm = x[162:170,1];        PWE = x[171:179,1];
M = x[180:188,1];        E = x[189:197];           Q = x[198:206,1];
PQ = x[207:215,1];       Fbar = x[216,1];          CPI = x[217,1];
GDP = x[218,1];          RGDP = x[219,1];          EXPINF = x[220,1];
R = x[221,1];            Pa = x[222,1];            TFPR = x[223,1];
Z = x[224:232,1];        RKI = x[233:241,1];       ri = x[242:250,1];
spi = x[251:259,1];      AR = x[260,1];
Hplus1 = x[261:269,1];   Kplus1 = x[270:278,1];
Lfplus1 = x[279:287,1];  LSplus1 = x[288:296,1];   Educ = x[297,1];
eff = x[298,1];          LUSplus1 = x[299:307,1];  YHbar = x[308,1];
Gini = x[309,1];         Theil = x[310,1];         EVA = x[311,1];
EVS = x[312,1];          EVU = x[313,1];
EVI = x[314,1];          EVC = x[315,1];



                                  @ set-up equations of model @

/*------------------------Production Function------------------------*/

vf[1:9,1] =O - TFPR.*AVA.*(lus^(alphaU).*(ls)^(alphaS).*
K^(1-alphaU-alphaS));

/*-----------------------------net prices----------------------------*/

 vf[10:18,1] = PV - (PD - tau.*PQ - A'PD);

/*-----------------------------Labor Market--------------------------*/

 vf[19:27,1] = PV.*alphaU.*O - (LUS.*WUSK)./1000000000;

 vf[28:36,1] = PV.*alphaS.*O - (LS.*WSK)./1000000000;

 Vf[37:45,1] = LUS - LUSD;

 vf[46:54,1] = LS - LSD;
```

```
/*---------------------Income-Saving-Consumptions--------------------*/

vf[55,1] = Ywusk -(LUS'WUSK./1000000000);    @ Unskilled Wages Bill @

vf[56,1] = Ywsk  -(LS'WSK./1000000000) ;     @ Unskilled Wages Bill @

vf[57,1] = Yk - (PV'O - (LUS'WUSK./1000000000) -

           (LS'WSK./1000000000));                @ Sectoral Profit @

vf[58,1] = Yg - hinc't - tau'O - tm'M - tex'O -

           WTG.*ER;                             @ Government Income@

vf[59:63,1] = Hinc - (Ywusk.*HFSH1 + Ywsk.*HFSH2 + Yk.* HFSH3

             + WTH.*ER + GTHTOT*GTH./Sumc(GTH)).*(1-t);   @ Household
                                                     Disposable Income @

vf[64:68,1]= Hsav - MPS.*Hinc;                  @ Household Saving @

vf[69:77,1]= HAcom - gamaHA - hams.*((Hinc[1,1]-Hsav[1,1])

             -sumc(PQ.*gamaha))./PQ;                  @Agriculture
                                            Household Consumptions LES @

vf[78:86,1] =Hscom - gamaHs - hsms.*((Hinc[2,1]-Hsav[2,1])

            -sumc(PQ.*gamahs))./PQ;             @Skilled Household
                                                  Consumptions LES @

vf[87:95,1] = HUcom - gamaHU - HUms.*((Hinc[3,1]-Hsav[3,1])

              -sumc(PQ.*gamahu))./PQ;          @Unskilled Household
                                                  Consumptions LES @

vf[96:104,1]= HIcom - gamaHI - HIms.*((Hinc[4,1]-Hsav[4,1])

             -sumc(PQ.*gamahi))./PQ;            @Informal Household
                                                 Consumptions LES @

vf[105:113,1]= HCcom - gamaHC - HCms.*((Hinc[5,1]-Hsav[5,1])

                         -sumc(PQ.*gamahc))./PQ;  @Capitalist
                                          Household Consumptions LES @

vf[114:122,1] = GCom - gcfc.*GCtot./PQ;     @ Government Consumptions @

vf[123:131,1] = TC - HAcom - HScom - HIcom -HUCom

                     - HCcom - Gcom;           @ Total Comsumption @

vf[132,1] = Gexp -  Sumc(PQ.*Gcom) - sumc(GTH)
            - GTW;                        @ Goverment Expenditures @

vf[133,1] = GS - (Yg-Gexp);                    @ Government Saving @

vf[134,1] = TS - sumc(hsav)- GS - Fbar;             @ Total Saving @

vf[135:143,1] = U - Sij'PD;              @ Vector of Capital Price @

vf[144:152,1] = Zo - (Sij)*(H.*TS./U); @ TOTAL SECTORAL INVESTMENT @
```

```
/*-------------------PRODUCT MARKET EQUILIBRIUM---------------------*/
 vf[153:160,1] = DF*(O.*PD-(PQ.*A*O + PQ.*TC
   + PQ.*Z - Pm.*M + PQ.*E - tex.*O - tm.*M)) @ @Supply = Demand Walras Law

vf[161,1] = (O/sumc(O))'Pd - Pa;    @Price Normalization Equation @

 /*----------------------Int'l Trade--------------------------------*/

 vf[162:170,1] = pm - pwbar.*(1+tm).*er;              @ Import Price @

 vf[171:179,1] = Pwe - PD./((1+te).*er);              @ Export Price @

 VF[180:188,1] = M - (TC+A*O+Z-M).*((PD./PM).*

        (LandaQ./(1-landaq)))^(1./(1+rhoq)); @ Import Demand Equation@

 vf[189:197,1] = E -(TC+A*O+Z-M).*((PD./Pwe).*

     (LandaED./(1-landaED)))^(1./(1+rhoED)); @Export Demand Equations@

 vf[198:206,1] = Q - AQ.*(landaQ.*(M)^(RhoQ) + (1-landaQ).*

     (TC+A*O+Z-M)^(rhoQ))^(1./rhoQ);       @Supply of Composite Goods@

 vf[207:215,1] = PQ - (PD.*(TC+A*O+Z-M) + PM.*M)

                 ./Q;                     @ Composite Price Equation @

 vf[216,1] = (PWE'E + 74.40 ) - (PM'M + 11.95) + fbar;
               @ Balance of Payment @

 /*--------------------------MACROECONOMICS-------------------------*/

 vf[217,1] = CPI-FC'PQ;                        @ CONSUMER PRICE INDEX @

 vf[218,1] =GDP - Ywusk - Ywsk - Yk - Yg + WTG + Sumc(wth)+ Fbar;
                          @SUMC(PDo.*O) + SUMC(PQo.*A*O) NOMINAL GDP @

 vf[219,1]= RGDP - (GDP./Pa);                                @ REAL GDP@

 vf[220,1]= EXPINF -100*(CPI-CPIo)/CPIo;         @ EXPECTED INFLATION @

 vf[221,1] = R - (3.5 - EXPINF);                 @ REAL INTEREST RATE @

 vf[222,1] = Pa - GDP./RGDP;                    @ OVERALL PRICE LEVEL @


 /*-------------------------Total Factor Productivity-----------------*/

 vf[223,1] = TFPR - landa.*(GIFINV.*GrowthIF)^MU;

/*---------------------Investment------------------------------------*/

 vf[224:232,1] = Z - (H.*TS./U);                 @REAL INVESTMENT BY
                                                 SECTOR OF DESTINATION@

 vf[233:241,1] = RKI -((1 - alphaS - alphaU).*PV.*O);  @Sectoral Profit@

 vf[242:250,1] = ri -(rki./(U.*K))
                           @+ (U - Ulag)./Ulag@; @Sectoral Profit Rate@

 vf[251:259,1] = spi - rki./sumc(rki);            @Sectoral Share
                                                   in Aggregate Profit@
```

```
 vf[260,1] = Ar - SPI'ri;                         @Average Profit Rate@

 vf[261:269,1] = Hplus1 - (spi + spi.*(ri -ar)./ar); @ Sectoral Shares
                                                      of investment t+1 @

 vf[270:278,1] = Kplus1 - (K + Z);            @ Sectoral Capital Stock @

/*-------------------------Labor Dynamic-------------------------------*/

vf[279:287,1] = LFplus1 - (1+nl).*LF;        @ Labor Force Growth Rate @

vf[288:296,1] = LSplus1-LS-Educ.*SharED; @Growth of Skilled Labor Force@

vf[297,1] = EDUC - eff.*enr;                    @ Educated Labor Force @

vf[298,1] = eff-landaHC.*(GHCINV.*GrowthHC)^MU; @ efficiency of
                                                   education production @

vf[299:307,1] = LUSplus1 - LFplus1 + LSplus1;

/*----------------------Income Distributions----------------------------*/

vf[308,1] = YHbar - sumc(hinc)/5;                          @ Mean Income @

vf[309,1] = Gini - (abs(Hinc[1,1] -Hinc[2,1]) + abs(Hinc[1,1] -Hinc[3,1])
            + abs(Hinc[1,1] -Hinc[4,1])+ abs(Hinc[1,1] -Hinc[5,1])
            + abs(Hinc[2,1] -Hinc[1,1])+ abs(Hinc[2,1] -Hinc[3,1])
            + abs(Hinc[2,1] -Hinc[4,1])+ abs(Hinc[2,1] -Hinc[5,1])
            + abs(Hinc[3,1] -Hinc[1,1])+ abs(Hinc[3,1] -Hinc[2,1])
            + abs(Hinc[3,1] -Hinc[4,1])+ abs(Hinc[3,1] -Hinc[5,1])
            + abs(Hinc[4,1] -Hinc[1,1])+ abs(Hinc[4,1] -Hinc[2,1])
            + abs(Hinc[4,1] -Hinc[3,1])+ abs(Hinc[4,1] -Hinc[5,1])
            + abs(Hinc[5,1] -Hinc[1,1])+ abs(Hinc[5,1] -Hinc[2,1])
            + abs(Hinc[5,1] -Hinc[3,1])+ abs(Hinc[5,1] -Hinc[4,1])
             )/(50*yhbar);                    @ Gini Coffecient Based
                                                           on Income @

vf[310,1] = Theil -((hinc[1,1]/yhbar)*log(hinc[1,1]/yhbar)
             + (hinc[2,1]/yhbar)*log(hinc[2,1]/yhbar)
             + (hinc[3,1]/yhbar)*log(hinc[3,1]/yhbar)+
              (hinc[4,1]/yhbar)*log(hinc[4,1]/yhbar)+
             (hinc[5,1]/yhbar)*log(hinc[5,1]/yhbar))/5;  @ Theil Index
                                                       Based on Income @

/*--------------------------Welfare Measure---------------------------*/

vf[311,1] = EVA - prodc((PQo./PQ)^hams)*(Hinc[1,1]-PQ'Gamaha) + (Hinc0[1,1]-
PQo'Gamaha);

vf[312,1] = EVS - prodc((PQo./PQ)^hsms)*(Hinc[2,1]-PQ'Gamahs) + (Hinc0[2,1]-
PQo'Gamahs);

vf[313,1] = EVU - prodc((PQo./PQ)^hums)*(Hinc[3,1]-PQ'Gamahu) + (Hinc0[3,1]-
PQo'Gamahu);

vf[314,1] = EVI - prodc((PQo./PQ)^hims)*(Hinc[4,1]-PQ'Gamahi) + (Hinc0[4,1]-
PQo'Gamahi);

vf[315,1] = EVC - prodc((PQo./PQ)^hcms)*(Hinc[5,1]-PQ'Gamahc) + (Hinc0[5,1]-
PQo'Gamahc);
```

```
retp (vf);
endp;
/*=========================the cge model==========================*/
__altnam = {VA1, VA2, VA3, VA4, VA5, VA6, VA7, VA8, VA9,

            "PV1", "PV2", "PV3", "PV4", "PV5", "PV6", "PV7",
            "PV8", "PV9",

            LUSD1, LUSD2, LUSD3, LUSD4, LUSD5, LUSD6, LUSD7,
            LUSD8, LUSD9,

            LSD1, LSD2, LSD3, LSD4, LSD5, LSD6, LSD7, LSD8, LSD9,

            "WUSK1", "WUSK2", "WUSK3", "WUSK4", "WUSK5", "WUSK6",
            "WUSK7", "WUSK8", "WUSK9",

            "WSK1", "WSK2", "WSK3", "WSK4", "WSK5", "WSK6", "WSK7",
            "WSK8", "WSK9",

            "YWusk", "Ywsk", "Yk", "Yg",

            "HINC1", "HINC2", "HINC3", "HINC4", "HINC5",

            "Hsav1", "Hsav2", "Hsav3", "Hsav4", "Hsav5",

            "HAcon1", "HAcon2", "HAcon3", "HAcon4", "HAcon5",
             "HAcon6", "HAcon7", "HAcon8","HAcon9",

            "HScon1", "HScon2", "HScon3", "HScon4", "HScon5",
             "HScon6", "HScon7", "HScon8","HScon9",

            "HUcon1", "HUcon2", "HUcon3", "HUcon4", "HUcon5",
            "HUcon6", "HUcon7", "HUcon8","HUcon9",

            "HIcon1", "HIcon2", "HIcon3", "HIcon4", "HIcon5",
            "HIcon6", "HIcon7", "HIcon8","HIcon9",

            "HCcon1", "HCcon2", "HCcon3", "HCcon4", "HCcon5",
            "HCcon6", "HCcon7", "HCcon8","HCcon9",

            "Gcom1", "Gcom2", "Gcom3", "Gcom4", "Gcom5",
            "Gcom6", "Gcom7", "Gcom8", "Gcom9",

            TC1, TC2, TC3, TC4, TC5, TC6, TC7, TC8, "TC9",

            "Gexp", "GS", "TS",

            U1, U2, U3, U4, U5, U6, U7, U8, "U9",

            ZO1, ZO2, ZO3, ZO4, ZO5, ZO6, ZO7, ZO8, "ZO9",

            "PD1", "PD2", "PD3", "PD4", "PD5", "PD6", "PD7",
            "PD8", "PD9",

            "PM1", "PM2", "PM3", "PM4", "PM5", "PM6", "PM7",
             "PM8", "PM1",

            "PWE1", "PWE2", "PWE3", "PWE4", "PWE5", "PWE6",
            "PWE7", "PWE8", "PWE9",

             M1, M2, M3, M4, M5, M6, M7, M8, "M9",

             E1, E2, E3, E4, E5, E6, E7, E8, "E9",
```

```
             Q1, Q2, Q3, Q4, Q5, Q6, Q7, Q8,

             "Q9", PQ1, PQ2, PQ3, PQ4, PQ5, PQ6, PQ7,
             PQ8, "PQ9",

              "fbar", "CPI", "GDP", "RGDP", "EXPINF", "R",
              "Pa", "TFPR",

              Z1, Z2, Z3, Z4, Z5, Z6, Z7, Z8, "Z9",

              Rki1, Rki2, Rki3, Rki4, Rki5, Rki6, Rki7, Rki8,
              "Rki9",

              ri1, ri2, ri3, ri4, ri5, ri6, ri7, ri8, "ri9",

              Spi1, Spi2, Spi3, Spi4, Spi5, Spi6, Spi7, Spi8,
              "Spi9",

              "ar", "H1(t+1)", "H2(t+1)", "H3(t+1)", "H4(t+1)",
              "H5(t+1)", "H6(t+1)", "H7(t+1)", "H8(t+1)",
              "H9(t+1)",

              "K1(t+1)", "K2(t+1)", "K3(t+1)", "K4(t+1)",
              "K5(t+1)", "K6(t+1)", "K7(t+1)", "K8(t+1)",
              "K9(t+1)",

              "LF1(t+1)", "LF2(t+1)", "LF3(t+1)", "LF4(t+1)",
              "LF5(t+1)", "LF6(t+1)", "LF7(t+1)", "LF8(t+1)",
              "LF9(t+1)",

              "LS1(t+1)", "LS2(t+1)", "LS3(t+1)", "LS4(t+1)",
              "LS5(t+1)", "LS6(t+1)", "LS7(t+1)", "LS8(t+1)",
              "LS9(t+1)", "educ", "eff",

              "LU1(t+1)", "LU2(t+1)", "LU3(t+1)", "LU4(t+1)",
               "LU5(t+1)", "LU6(t+1)", "LU7(t+1)", "LU8(t+1)",
               "LU9(t+1)", "YHbar",

              "Gini", "Theil", "EVA", "EVS", "EVU", "EVI", "EVC"};

 output file = K:results reset;

__nlagr = 2;

__title = "Niger CGE Model: Base Run0";

{x1,tcode} = eqSolve(&fsys,x0);

Period0 = X1;

/*----------------------------------------------------------------
-------------------------------*/


x0 = x1;



    H = x1[261:269,1];
    K = x1[270:278,1];
   lf = x1[279:287,1];
   ls = x1[288:296,1];
```

```
   lus = x1[299:307];
   CPIo = x1[217,1];
   PQo = x1[207:215,1];
   enr1=23364;
   Hinc0 =x1[59:63,1];
   enr = enr1.*(1.03)^(2);
   Oo =x1[1:9,1];
   @GIFINV =17.4804 + 78.54/3;@
   GHCINV = 21.6424 + 78;
   @GTHTOT = 38.2 + 2*78/3;@
   @WTG =  59.4 + 78/3;@
   @GCtot =192.87 + 78.54/3;@



output file = K:results reset;
_nlagr = 2;
__title = "Niger CGE Model: Base Run1";
{x1,tcode} = eqSolve(&fsys,x0);
period1 = x1;

/*------------------------------------------------------------
------------------------------------*/


x0 = x1;



    H = x1[261:269,1];
    K = x1[270:278,1];
   lf = x1[279:287,1];
   ls = x1[288:296,1];
   lus = x1[299:307];
   CPIo = x1[217,1];
   PQo = x1[207:215,1];
   Hinc0 =x1[59:63,1];
   enr1=23364;
   enr = enr1.*(1.03)^(3);
   Oo =x1[1:9,1];


output file = K:results reset;
_nlagr = 2;
__title = "Niger CGE Model: Base Run2";
{x1,tcode} = eqSolve(&fsys,x0);
period2 = x1;

/*----------------------------------------------------------
------------------------------------*/

x0 = x1;



    H = x1[261:269,1];
    K = x1[270:278,1];
   lf = x1[279:287,1];
   ls = x1[288:296,1];
   lus = x1[299:307];
   CPIo = x1[217,1];
   PQo = x1[207:215,1];
   Hinc0 =x1[59:63,1];
```

```
   enr1=23364;
   enr = enr1.*(1.03)^(4);
   Oo =x1[1:9,1];


output file = K:results reset;
_nlagr = 2;
__title = "Niger CGE Model: Base Run3";
{x1,tcode} = eqSolve(&fsys,x0);
period3 = x1;

/*------------------------------------------------------------
------------------------------------*/

x0 = x1;



    H = x1[261:269,1];
    K = x1[270:278,1];
   lf = x1[279:287,1];
   ls = x1[288:296,1];
   lus = x1[299:307];
   CPIo = x1[217,1];
   PQo = x1[207:215,1];
   Hinc0 =x1[59:63,1];
   enr1=23364;
   enr = enr1.*(1.03)^(5);
   Oo =x1[1:9,1];


output file = K:results reset;
_nlagr = 2;
__title = "Niger CGE Model: Base Run4";
{x1,tcode} = eqSolve(&fsys,x0);
period4 = x1;

/*----------------------------------------------------------
------------------------------------*/

x0 = x1;



    H = x1[261:269,1];
    K = x1[270:278,1];
   lf = x1[279:287,1];
   ls = x1[288:296,1];
   lus = x1[299:307];
   CPIo = x1[217,1];
   PQo = x1[207:215,1];
   Hinc0 =x1[59:63,1];
   enr1=23364;
   enr = enr1.*(1.03)^(6);
   Oo =x1[1:9,1];


output file = K:results reset;
_nlagr = 2;
__title = "Niger CGE Model: Base Run5";
{x1,tcode} = eqSolve(&fsys,x0);
period5 = x1;
```

```
/*------------------------------------------------------------------------------
--------------------*/

x0 = x1;



    H = x1[261:269,1];
    K = x1[270:278,1];
   lf = x1[279:287,1];
   ls = x1[288:296,1];
   lus = x1[299:307];
   CPIo = x1[217,1];
   PQo = x1[207:215,1];
   Hinc0 =x1[59:63,1];
   enr1=23364;
   enr = enr1.*(1.03)^(7);
   Oo =x1[1:9,1];



output file = K:results reset;
_nlagr = 2;
__title = "Niger CGE Model: Base Run6";
{x1,tcode} = eqSolve(&fsys,x0);
period6 = x1;
/*-----------------------------------------------------------------------------
------------------------------------*/

x0 = x1;



    H = x1[261:269,1];
    K = x1[270:278,1];
   lf = x1[279:287,1];
   ls = x1[288:296,1];
   lus = x1[299:307];
   CPIo = x1[217,1];
   PQo = x1[207:215,1];
   Hinc0 =x1[59:63,1];
   enr1=23364;
   enr = enr1.*(1.03)^(8);
   Oo =x1[1:9,1];


output file = K:results reset;
_nlagr = 2;
__title = "Niger CGE Model: Base Run7";
{x1,tcode} = eqSolve(&fsys,x0);
period7 = x1;

/*---------------------------------------------------------------
------------------------------------*/

x0 = x1;



    H = x1[261:269,1];
    K = x1[270:278,1];
   lf = x1[279:287,1];
   ls = x1[288:296,1];
```

```
   lus = x1[299:307];
   CPIo = x1[217,1];
   PQo = x1[207:215,1];
   Hinc0 =x1[59:63,1];
   enr1=23364;
   enr = enr1.*(1.03)^(9);
   Oo =x1[1:9,1];



output file = K:results reset;
_nlagr = 2;
__title = "Niger CGE Model: Base Run8";
{x1,tcode} = eqSolve(&fsys,x0);
period8 = x1;


/*-----------------------------------------------------------------
-----------------------------------*/

x0 = x1;



    H = x1[261:269,1];
    K = x1[270:278,1];
   lf = x1[279:287,1];
   ls = x1[288:296,1];
   lus = x1[299:307];
   CPIo = x1[217,1];
   PQo = x1[207:215,1];
   Hinc0 =x1[59:63,1];
   enr1=23364;
   enr = enr1.*(1.03)^(10);
   Oo =x1[1:9,1];



output file = K:results reset;
_nlagr = 2;
__title = "Niger CGE Model: Base Run9";
{x1,tcode} = eqSolve(&fsys,x0);
period9 = x1;

/*----------------------------------------------------------------
-----------------------------------*/

x0 = x1;



    H = x1[261:269,1];
    K = x1[270:278,1];
   lf = x1[279:287,1];
   ls = x1[288:296,1];
   lus = x1[299:307];
   CPIo = x1[217,1];
   PQo = x1[207:215,1];
   Hinc0 =x1[59:63,1];
   enr1=23364;
   enr = enr1.*(1.03)^(11);
   Oo =x1[1:9,1];
```

```
output file = K:results reset;
_nlagr = 2;
__title = "Niger CGE Model: Base Run10";
{x1,tcode} = eqSolve(&fsys,x0);
period10 = x1;

/*--------------------------------------------------------------
-----------------------------------*/

x0 = x1;



    H = x1[261:269,1];
    K = x1[270:278,1];
   lf = x1[279:287,1];
   ls = x1[288:296,1];
   lus = x1[299:307];
   CPIo = x1[217,1];
   PQo = x1[207:215,1];
   Hinc0 =x1[59:63,1];
   enr1=23364;
   enr = enr1.*(1.03)^(12);
   Oo =x1[1:9,1];

output file = K:results reset;
_nlagr = 2;
__title = "Niger CGE Model: Base Run11";
{x1,tcode} = eqSolve(&fsys,x0);
period11 = x1;

/*-----------------------------------------------------------------
-----------------------------------*/
 @
x0 = x1;



    H = x1[261:269,1];
    K = x1[270:278,1];
   lf = x1[279:287,1];
   ls = x1[288:296,1];
   lus = x1[299:307];
   CPIo = x1[217,1];


output file = K:results reset;
_nlagr = 2;
__title = "Niger CGE Model: Base Run12";
{x1,tcode} = eqSolve(&fsys,x0);
period12 = x1;

/*------------------------------------------------------------
----------------------------------*/
x0 = x1;



    H = x1[261:269,1];
    K = x1[270:278,1];
   lf = x1[279:287,1];
   ls = x1[288:296,1];
```

```
   lus = x1[299:307];


output file = K:results reset;
_nlagr = 2;
__title = "Niger CGE Model: Base Run13";
{x1,tcode} = eqSolve(&fsys,x0);
period13 = x1;

/*------------------------------------------------------------
-----------------------------------*/
x0 = x1;



    H = x1[261:269,1];
    K = x1[270:278,1];
   lf = x1[279:287,1];
   ls = x1[288:296,1];
   lus = x1[299:307];


output file = K:results reset;
_nlagr = 2;
__title = "Niger CGE Model: Base Run14";
{x1,tcode} = eqSolve(&fsys,x0);
period14 = x1;

/*---------------------------------------------------------------
-----------------------------------*/
x0 = x1;



    H = x1[261:269,1];
    K = x1[270:278,1];
   lf = x1[279:287,1];
   ls = x1[288:296,1];
   lus = x1[299:307];


output file = K:results reset;
_nlagr = 2;
__title = "Niger CGE Model: Base Run15";
{x1,tcode} = eqSolve(&fsys,x0);
period15 = x1;
/*----------------------------------------------------------------------*/
@

names = __altnam;

Y = names~period0~period1~period2~period3~period4~period5~period6
     ~period7~period8~period9~period10~period11;

let mask[1,13] = 0 1 1 1 1 1 1 1 1 1 1 1 1;

let fmt[13,3] =
    "_*.*s " 7 7
    "*.*lf" 12 3
    "*.*lf" 12 3
    "*.*lf" 12 3
    "*.*lf" 12 3
    "*.*lf" 12 3
```

```
    "*.*lf" 12 3
    "*.*lf" 12 3
    "*.*lf" 12 3
    "*.*lf" 12 3
    "*.*lf" 12 3
    "*.*lf" 12 3
    "*.*lf" 12 3;
lprint;
d = printfm(Y,mask,fmt);
output file = K:\NigerCGEModel\cgeoutput;
```

VITA

Issoufou Soumaila

Candidate for the Degree of

Doctor of Philosophy

Thesis: A GENERAL EQUILIBRIUM ANALYSIS OF POTENTIAL USE OF NATURAL RESOURCES REVENUE IN NIGER

Major Field: Economics

Biographical:

Personal Data: Born in Dosso, Niger, the son of Mintou S. and Soumaila N.

Education: Received Bachelor of Art in Economics at University of Central Oklahoma, Edmond, Oklahoma. Completed the requirements for the Doctor of Philosophy in Economics at Oklahoma State University, Stillwater, Oklahoma in December, 2008.

Experience: Research Assistant, Aug. 2004-Jul. 2005, Center for Applied Economic Research, Oklahoma State University; Research Associate, Aug. 2005-May. 2006, Center for Applied Economic Research, Oklahoma State University; Teaching Associate, June 2006-Aug. 2008, Economics Department, Oklahoma State University.

Professional Memberships: American Economic Association, Southern Economic Association

Name: Issoufou Soumaila Date of Degree: December, 2008

Institution: Oklahoma State University Location: Stillwater, Oklahoma

Title of Study: A GENERAL EQUILIBRIUM ANALYSIS OF POTENTIAL USE OF NATURAL RESOURCES REVENUE IN NIGER

Pages in Study: 154 Candidate for the Degree of Doctor of Philosophy

Major Field: Economics

Scope and Method of Study: The literature on "Dutch disease" emphasizes that an inflow of natural resource windfall in a country causes an appreciation of real exchange, thereby reducing the country's competitiveness. This phenomenon has triggered policy makers in countries expecting a natural resources windfall to ask the following question: how can countries avoid the Dutch disease? Although there is extensive literature on how to escape the Dutch disease, only very few studies have gone on to model the economy-wide impact of specific set of policy prescribed to deal with the Dutch disease. The following study contributes to the literature by using a dynamic computable general equilibrium model to quantify the effect of two investment policies on Niger's economy. First, the model is built and calibrated to a 2004 Social Accounting Matrix and one simulation is performed. In the simulation, the government is assumed to save half of the windfall and transfer the other half to each of the representative household groups in the model. Second, the model is modified and is used to quantify the use of natural resources revenue for investment in education and infrastructure.

Findings and Conclusions: The result of the first simulation shows that a resource windfall is growth promoting. However compared to the baseline, natural resource rent increases the overall price level and income inequality. When the windfall is invested in education or infrastructure, we get a higher level of gross domestic product (GDP) than obtained in the first simulation but also a lower price level and lower Gini coefficient. However superior results are obtained when the windfall is invested simultaneously in education and infrastructure, which implies a complementary effect between the two investment strategies. The policy implication of the study is that natural resource revenue in Niger should be invested in education and infrastructure to reduce the risk of Dutch disease and to promote economic prosperity.

ADVISER'S APPROVAL: Dr. Michael Applegate